CROSBY-FISKE-FORSTER
HAND BOOK
OF
FIRE
PROTECTION

SEVENTH EDITION

D. VAN NOSTRAND COMPANY
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George J. Koepke

CROSBY-FISKE-FORSTER

HAND-BOOK
OF
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BY

EVERETT U. CROSBY
HENRY A. FISKE
H. WALTER FORSTER

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George J. Koepke

RESPECTFULLY DEDICATED TO

UBERTO C. CROSBY

ORIGINATOR OF THE NATIONAL FIRE PROTECTION ASSOCIATION
AND ONE OF ITS FIRST PRESIDENTS

KNOWN FOR HIS UNWAVERING PROMOTION OF ORGANIZED FIRE
PROTECTION AND THE ATTENDANT REDUCTION OF
INSURANCE COSTS,—YET ABOVE ALL FOR
THE KINDLY SYMPATHY OF A
GREAT HEART

PREFACE

1. It is now the privilege of the authors to present to students of fire prevention and protection the Seventh Edition of the Crosby-Fiske-Forster Handbook of Fire Protection. The preceding editions, beginning with the first book in 1896, have aimed to provide in reliable, compact form all that the passage of time has crystallized into good practice. The Sixth Edition met with unprecedented success; distribution exceeded that of any fire protection handbook published in the English language. The Seventh Edition marks another step forward, not only in additional and improved text, but also in illustrating, cross-referencing, and indexing.

2. The book continues to serve as a basis of education for beginners in the fields of fire prevention and protection, as the constant companion of experienced men specializing in these fields, and as a reference work for those who occasionally desire specific facts of this character.

3. As in previous editions, the authors desire to express appreciation of the constructive criticism received from many sources and of generously having had a mass of material made available to them for analysis in the preparation of the new book.

THE AUTHORS

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CHAPTER 1

FUNDAMENTAL PRINCIPLES OF FIRE PROTECTION

1. The readers of this book are unquestionably familiar, in a general way, with the tremendous fire waste of this country It is a waste made up of the destruction and damage of property by fire, water, and smoke, of the cost of public and private fire protection, of the conduct of the insurance business, and of law making, inspection, and allied costs which states and cities incur. For the years 1916–1920 inclusive, the loss to property upon which insurance was carried averaged $267,600.000. Making an allowance for uninsured losses and adding the costs other than direct property damage, produces an average annual fire cost fully as much as $500,000,000, a per capita cost of about $5. The life loss through fire is variously estimated at from 10,000 to 15,000 per year. See page 30 for table of causes of loss.

2. Something like 350,000 fires are reported per year, most of which are due to carelessness or ignorance. All were small at the start and therefore subject to control, and practically all by proper building construction and arrangement and by adequate protection could have been prevented from causing appreciable damage.

3. The far better fire records of the leading European nations show what can be done on a large scale to prevent fire outbreak, its serious spread, and to minimize the jeopardy of life. Practically perfect fire records of hundreds of American industrial plants over long periods of years show what can be done in this country by intelligent construction, protection, and care. Many plants are now paying insurance premiums in the vicinity of 10c per $100 of insurance per year. Underwriters consider a 50% loss ratio satisfactory. There has therefore on such plants been available on the average 5c per year for losses against a $100 risk; or, putting it another way, the underwriters are wagering 2000 to 1 against a total loss in any one year. As a matter of fact, the actual fire loss in the best manufacturing plants and mercantile properties is running from 2 to 3c per $100 per year.

4. There are three principal reasons for improving plants from a fire prevention and fire protection standpoint, the first, safeguarding life, the second, safeguarding business against interruption by fire, the third, insurance cost reduction. Safeguarding property generally cuts insurance costs, but the organization or individual desiring the maximum in the way of life and property safety, generally goes far beyond the minimum requirements of the Underwriters. For example, the provision of fire doors fairly well maintained may entitle a plant to an insurance credit, but attention to every detail that makes for maximum fire door efficiency involves perhaps twenty points that no rating schedule covers. Again, while an insurance charge may be made when the order and cleanliness of a property are distinctly poor, no financial inducement is, as a rule, made to a property owner to exercise superlative care along these lines.

5. The best managed properties are those where every practical precaution is taken to avoid fire for the primary purpose of safeguarding life and preventing interruption of business by fire, and where advantage is taken, in connection with any improvement, of the lowest available insurance rate consistent with sound underwriting.

6. The fire prevention and fire protection problem resolves itself into preventing the outbreak of fire, preventing the serious spread of fire, and providing for the prompt detecting and extinguishing of fire. If complete fire prevention were possible, there would be no need of attention to the other two parts of the problem. If the construction of the buildings could be such that no fire could spread beyond a small area, fire prevention and fire extinguishing would be of minimum importance. If absolute control of every fire that broke out were possible, preventing outbreak and spread of fire could be dropped from consideration. While one or more of these conditions is approached in modern plants, proper attention to the fire safety problem always warrants a consideration of all phases of the problem, and usually action along all lines. To know how to secure, with the least effort, expense, and interference with business, the greatest practical measure of safety and financial return frequently requires wide knowledge of past experience and nice judgment in the case in question.

7. In considering the advisability of any fire protection improvement, the wisdom of the step may be tested by asking one's self the following questions:

a—Does the fire risk justify any cost over and above that on which an acceptable return is secured through reduced insurance premium? Sometimes money is literally no object where certain hazards must be eliminated, but generally the same point of view that makes for successful management in other directions is essential in successfully furthering fire protection.

b—Is it the best fire protection improvement costing about the same amount of money? Will any permanent interruption of, or inconvenience to, or increased cost of, operations result? Occasionally improvements must interfere with operations, but almost always this can be avoided. The measure of capacity of a fire protection engineer may almost be said to be his ability to work *with* the operating force.

c—Does what is proposed fit into the ultimate plant development so far as it can be anticipated? Proceeding without foresight is as inadvisable in fire protection as in any other activity.

8. It is essential that cognizance be taken of fire risk to records of every character, and to drawings, dies, patterns, and similar property, frequently of great value and often incapable of replacement in part at least. Such values often greatly exceed those of the buildings in which located, and some of these values are seldom insured, making prevention of fire all the more necessary.

9. The modern tendency is to have plants appraised with a high degree of accuracy and to keep such appraisals up to date. From a fire protection standpoint a knowledge of values is important in order to prove the need of safeguarding and to determine the degree to which improvements are warranted. For proper placing of insurance and for prompt loss adjustment a reliable appraisal is invaluable.

10. The executive responsible for the plant safety and output, and the fire protection engineer, whether connected with the plant or coming in from the outside, must have in mind the fundamental principles of fire protection in order to secure the best results in the long run.

CHAPTER 2

FIRE PROTECTION AN ENGINEERING SCIENCE

1. The work of the National Fire Protection Association, National Board of Fire Underwriters, Underwriters' Laboratories, Bureau of Standards, and other agencies, has produced excellent standards bearing on construction, control of hazards, and protection. They are available for the asking, and at first glance it might seem that there was little need of the application of specific engineering skill to problems of this character. The reverse, however, is the case, especially in connection with new construction, and, where structural alterations are being undertaken or expensive equipment installed, it is wise to have a trained fire protection engineer review the plans and specifications. This was never so well illustrated as during the late war, when the United States Government, both at home and abroad, marshalled the finest fire protection brain power in the cause of non-interruption of program and prevention of loss of property. Truly remarkable results were secured under exceedingly difficult conditions.

2. Illustrations of the types of problems that require mature fire protection engineering judgment are set forth in the following paragraphs:

a—**Future growth of property.** The future growth of a prosperous American plant is a foregone conclusion, and many of the chief fire weaknesses existing to-day in important plants are due to a lack of foresight from a fire protection standpoint. The feeling that construction would be temporary in particular has resulted in serious exposures to important buildings and combustible connections between better built structures. The fire protection engineer often must literally force a consideration of the probable growth of the plant as regards area, building heights, and even manufacturing processes.

b—**Protecting structural steel.** To protect the steel in a contemplated building may cost as much or more than to install automatic sprinklers. If the contents are to be combustible, the exposed steel construction with sprinklers will produce greater safety and a lower fire insurance rate than an unsprinklered building with protected steel. If the structure is important, especially if high, both forms of protection are, of course, advisable, but if only sufficient funds are available for one step, unprotected steel and sprinklers would be better. However, if there is a likelihood that money enough for the additional step will be available later on, the fireproofing should go in at the outset, because this cannot be readily added later, whereas sprinklers can be installed in any type of building without appreciable difficulty or inconvenience.

c—**Reducing areas.** When existing admittedly unsatisfactory conditions are to be corrected, interesting problems often present themselves, as in the case of a large area, combustible building which was to be subdivided. The first thought was to put in several heavy, expensive fire walls, but in discussing future construction plans it developed that it would be feasible to break up the large area by two sections of fire resistive construction which would fit into the ultimate reconstruction plans.

d—**Special hazards.** The well-established rule that automatic sprinklers cover a multitude of sins, and make virtually any form of construction safe, does not hold where corrosion may render the heads ineffective or fire in inflammable liquids be difficult or incapable of control by sprinklers. Cutting off certain sections, incombustible construction, and use of small fire areas if wooden roofs are to be employed, are among the logical answers to this problem.

e—**Water supplies.** Water supplies, especially distributing mains, are commonly outgrown, and a policy of never laying less than 8″ mains, and occasionally even larger trunk lines, has provided better protection and prevented costly and inconvenient replacement of piping. The difference in cost between a 6″ and an 8″ pipe is ordinarily about 75c per ft. laid. At 8% interest, depreciation, and repairs, this represents about 6c per ft. per year, or $60 per year for a 1,000-ft. installation. The friction loss in 8′ pipe is one quarter that in 6″ pipe, a very important fire protection factor.

f—**Outside hose vs. sprinklers.** In another case, a plant with a moderate inherent fire hazard suffered serious external exposure. The question was whether the limited funds available should be put into an outside protective system, that is, water supply, hydrants, and hose, or be used for installing automatic sprinklers. After balancing all factors, it was decided to install the water supply and hydrant system arranged to permit the addition of sprinklers later on without any cost greater than the removal of plugs in tees conveniently left for future sprinkler work.

g—**Watchman vs. sprinklers.** Problems that involve the balancing of the advantages and disadvantages of alternative procedures are not uncommon. Many smaller plants, in particular, have had to decide whether it was advisable to continue a watchman at perhaps $900 per year salary or to install automatic sprinklers with central station supervision and to dispense with the watchman. The cost of a $6000 sprinkler installation, figuring interest, depreciation, and upkeep at 15%, would equal the watchman's salary. The fire protection value of the sprinklers would, of course, be far superior, but the theft protection feature of the watchman would have to be sacrificed.

3. The purpose of this chapter is to point out that a high order of technical knowledge and good engineering and business judgment may be required to handle important fire protection problems. When technical skill and sound judgment are applied to fire protection problems, the management of the average plant welcomes advice along these lines.

CHAPTER 3

RELATION OF ACCIDENT PREVENTION TO FIRE PREVENTION

1. Practically every fire is an accident, and many accidents are fires. Both are largely preventable, and frequently by the same methods. Engineers specializing in either subject must have at least a fundamental knowledge of the other, particularly since industrial plants commonly put both forms of preventive activity under the same man or department.

2. The direct cost in the United States of fires has been placed at fully $500,000,000 annually. The annual cost of accidents in which persons are injured or killed has been placed at $1,000,000,000, and of all accidents at between four and five billion dollars. The combined drain on lives and resources is enormous. The fire prevention conservation movement is decades old; the accident prevention one much younger, but its growth has been so rapid that the two subjects may be said to have equal importance in the eyes of the public and particularly in those of the employers to whom the financial burden of needless fires and accidents is more evident than to the ordinary citizen.

3. The purpose of this chapter is to point out the need and the advantages of taking into account the relation of accident prevention to fire prevention in plant construction, equipment, operation, and maintenance.

GENERAL PRINCIPLES.

4. Before taking up details, the following general principles may be stated:

a—No fire prevention or protection measures should introduce any avoidable life risks. For example, drilling a fire brigade in a littered up yard and with poor illumination is dangerous and inadvisable, but it is recognized that even under the best physical conditions such a drill has inherent hazards which must be incurred if the larger measure of plant safety is to be secured.

b—No fire prevention or protection measures should be taken without considering if some collateral accident prevention advantage cannot be obtained. For example, if better access to a sprinkler tank is to be provided, it may be feasible to carry a stair to the roof of a building nearby, securing to this roof needed access, and then continue the stairs or a ladder up the tank from that point.

c—No accident prevention step should be considered without attempting to secure a fire prevention benefit. For example segregating a hazardous department or process to minimize exposure of persons to explosions, flash fires, or fumes gives an opportunity to reduce fire risk. Also, provision of fire walls and enclosed stairs to facilitate exit, if properly done, decreases property risk.

d—Nothing that has value from both standpoints should be undertaken without having the design meet the best accident prevention engineering practice. For example, if a steam valve must be made readily accessible for operation in case of fire, the stair or ladder to it and the platform at the valve should accord with state and insurance accident prevention standards, and, occasionally, in the interest of the maximum practical safety, go even further than these requirements.

5. In the following sections appear specific examples of the relation of accident prevention to fire prevention:

ELECTRICITY.

6. The National Electric Safety Code, prepared by the Bureau of Standards, will unquestionably be adopted extensively by the States, and, since the principles of the Code meet with the approval of practically all interests, it should be studied and applied to electrical installations, especially new ones, from this time forward. The Safety Code and the National Electric (Fire) Code do not conflict, but rather supplement each other. Ample clearances where tensions are high, protection of exposed parts, general grounding of frames and cases of apparatus, and similar sound safety principles are essential features of the Code.

7. Link fuses are more of an accident than a fire hazard. Many men have been injured by bringing tools or other conductors across exposed link fuses or their terminals. Protection for many bare connections, fuses, switches, starting boxes, etc., is warranted from a safety standpoint.

8. Defective extension cords and lights have been responsible for a considerable number of deaths from electric shock, especially where portions of the man's body were grounded as in boilers or in wet places.

9. Definite grounding of all conduits and apparatus, even if of low voltage, is needed since the records indicate that many lives have been lost on voltages as low as 110.

10. Static electricity, a common cause of ignition of dust and vapors, by giving an unexpected shock, may cause serious falls.

11. High tension crosses, or lightning coming in over signalling system circuits not protected in the customary manner, carry with them serious accident possibilities.

FLASH FIRES AND EXPLOSIONS.

12. Flash fires igniting clothing are common causes of loss of life. In the few cases in which lives have been lost in sprinklered buildings, flash fires were generally the cause. The Newark Factory disaster of 1910, in which 25 lives were lost in a 3-story building, was due to the flashing of benzine. This building was not, however, sprinklered.

13. Dust explosions are a prolific cause of loss of life and property. A fire or a spark ignites the dust.

14. Japan oven explosions are not uncommon. One in New York in 1913 resulted in the loss of 8 lives and of much property.

HOUSEKEEPING.

15. Good housekeeping stands first both as a fire and accident prevention measure. Whereas incombustible refuse has little bearing on fire cause it has a great one on accident prevention and to secure both ends immaculate housekeeping conditions are imperative. "A place for everything and everything in its place" is an effective safety slogan.

16. Material which can fall from sprinkler tanks, roofs, elevated walkways, and other high places is particularly to be feared. Conditions at night and at the end of winter days must be taken into account as regards ordinary activities, and particularly those of the fire brigade.

PARAPETS ON WALLS.

17. Falls from roofs are not infrequent. Window cleaning, roof repairs, snow removal, and other causes take men to roofs. Roofs approximately flat can advantageously have a 3-ft. (minimum at any point) parapet on all outside walls. The fact that overhanging combustible roofs are a fire menace and that roof drains inside of building walls give less trouble in winter are arguments in favor of this form of construction.

FIRE DOORS.

18. The inherent life hazard of permitting doors to swing against the possible travel of a considerable number of people has been demonstrated time and again. The Iroquois Theater in which 600 lives were lost, is the best known example. Doors should swing with the travel or slide across it, except that sliding doors are not permitted on certain principal exits as for theatres or assembly halls.

19. Rolling shutters, which might be down or come down in case of fire, are inadvisable on main exits.

20. Slippery fire door sills, where good fire protection requires incombustible sills, are dangerous. Safety floor plates set in cement are excellent.

21. A watchman was killed by a gravity sliding fire door riding upon a piece of pipe left in the doorway and falling from the track, because the clearness between the door and the track exceeded the depth of the hanger wheel groove. This defect largely reduced the possibility of the door resisting serious fire.

22. Men have been painfully hurt by binders and fusible link brackets projecting into door openings at a dangerous height.

WINDOWS.

23. Modern practice requires large window areas and clean windows. Cleaning windows is decidedly hazardous work. Therefore, the type of window selected and the facilities for safe cleaning warrant earnest consideration. The extensive use of solid metal sash with windows of large area and with a comparatively small portion of the area pivoted often makes cleaning on the outside of high buildings almost impossible, except through the use of scaffolds or boatswain's chairs suspended from a trolley track running around the top of the building. Special window cleaning balconies are sometimes provided on the inside of high structures such as power houses. Special platforms on traveling cranes, bars across the tops of windows to which extension ladders can hook, and other safety provisions are made. Not to have a new building safe from this standpoint is evidence of lack of foresight on an important subject.

24. The use of wired glass, because less subject to breakage than ordinary glass, has become almost universal in skylights, monitors, and at other high points. It is quite generally used in exterior walls even of low buildings not exposed to fire. In partitions and doors and at other interior points it has safety advantages, because persons are occasionally badly hurt by falling through ordinary panes of glass.

ELEVATORS.

25. Fusible link controlled trap doors for elevator floor openings are ultra-hazardous, unless enclosed for six feet or more on all sides. The same thing is true of automatic hatch doors opened and closed by the cage in its travel. A standard shaft enclosure, with counterbalanced elevator doors or rolling shutters, arranged to be normally closed (electric interlock with the elevator engine) is ideal from a combined fire and accident prevention standpoint. If doors to shaft must be open during working hour, automatic sliding doors or rolling shutters, and safety gates in addition, are advised.

STAIRS.

26. Aside from the obvious points of sound stairs, uniform rise and tread, and equipment of hand rails, certain other safety features bearing on fire prevention warrant attention.

27. Automatic trap doors are dangerous. They are heavy, may fall, and are hard to raise when down. If the door is closed and persons rush or are crowded onto it in attempting to escape, the effect is exactly the same as the door swinging against the travel. (See Fig. 150, page 649.)

28. Stair enclosures should if possible have both natural and artificial illumination.

29. Fig. 29, page 203, illustrates a stair shaft with two forms of enclosure, the upper floors having stairs individually enclosed and the lower floors stairs in a shaft. The latter method obviously is superior, because persons are not called upon to pass into each story as they descend. Attention is called to the 42″ double hand rail, to 6″ toeboards, to signs over doors, and to exterior connection to the bottom stair hall.

30. A smoke proof tower, shown in Fig. 149, page 646, or a well enclosed interior stairway afford excellent positions from which to fight a fire.

ELEVATED TANKS.

31. Good fire protection practice requires fairly frequent climbing of a tank trestle for purposes of examination, but it is only on the rarest occasions that even a modern sprinkler tank is equipped so as to safeguard to a practical maximum the man in his climbing and inspection work. Particular attention is called to the chapter on gravity tanks, where in Fig. 52 are shown the various features which make for safety. New tanks should be thoroughly protected, and wherever old tanks contain such features as the following, improvement is necessary:

a—Ladder so close to columns or diagonal braces or other structural steel that person's feet are likely to strike these obstructions before resting securely on rungs. Minimum clearance between center of rungs and nearest point of structure should be 6½″.

b—Where spacing of rungs is not uniform, especially where sections of ladders connect, change should be made to bring about absolute uniformity. Men have been killed by just such a defect.

c—At no point should ladder slope backward from the vertical, for it is most dangerous to climb under such conditions. This situation is not infrequently found just below the tank platform.

d—Ample protection must be provided at the top of the ladder leading to the trap door in tank, so that a man can work on this trap door without being in imminent danger of falling.

32. When painting tank structure particular care should be exercised to avoid accidents.

33. Collapse of sprinkler tanks located on tops of buildings has been responsible for considerable life loss. Tanks, particularly large ones, should preferably be on independent structures well away from all important buildings. It placed on top of buildings, they should preferably be upon a rectangular stair or elevator shaft. Any existing installation should be carefully checked up for safety.

VALVES.

34. Many accidents occur or risks are incurred in connection with getting at valves in a fire system.

35. Pits should be sufficiently large to enable a man to work in them safely, should if possible have permanent ladder built into the walls or installed for convenient use, and should be free from sewer gas or other dangerous vapors.

36. Valves at ceilings or other high points should preferably be reached by a permanent ladder sufficiently far away from the wall to enable a man to put a foot through and hook his knee on one of the rungs. An even better method is to have a broad iron band at such a point that a man standing on the ladder can rest the small of his back against this and have both hands free.

37. Valves should if possible be placed where readily accessible from the ground or from some platform already installed, and at a sufficient height to avoid persons striking against them, particularly with the face. Placing gate or check valves immediately under tanks on trestles is particularly objectionable, because of difficulty of access.

HYDRANTS.

38. Hydrants should be placed where least likely to be run into in the ordinary travel about a plant, and it is good practice to paint them yellow so as to make them more prominent in poor light.

39. Where hose houses are erected over hydrants, the location of the lower shelf should be such that persons will not injure the hands in swinging a hydrant wrench. Many decidedly painful lacerations occur owing to insufficient clearance and to men working in a hurry.

HOSE.

40. Carts should have a sufficient gage so as not to be likely to upset on slopes and when making sharp turns.

41. Men have been injured and even killed by hoze nozzles getting away and striking men before they could get out of range. It is obvious that nozzle should be sufficiently manned before water is turned on, and that the practice of laying hose straight and with an easy upward curve is most desirable, because it prevents unnecessary side strains.

42. Hose, when tested, should be entirely free from air as, otherwise, a coupling which blows off may be projected with tremendous force.

CHEMICAL EXTINGUISHERS.

43. Accidents have occurred owing to narrow gage chemical engines being upset in mill yards, and a broad gage is desirable for an engine used outside.

44. The condition of chemical engines and of hand chemical extinguishers from the standpoint of corrosion and possible explosion warrants careful consideration and periodic attention. Men have been badly injured and even killed by caps blowing off, shells bursting, hose letting go, and bottoms blowing out. Any appreciable evidence of corrosion should bar the device from use and it should be returned to the manufacturer who should scrap it if it is not safe to re-line it Extinguishers bearing labels of Underwriters' Laboratories are especially safeguarded against corrosion.

AUTOMATIC SPRINKLERS.

45. Unquestionably, one of the greatest life savers ever invented is the automatic sprinkler. The life loss that has taken place in sprinklered buildings has been exceedingly small considering the number of persons exposed, and there never has been anything resembling a fire disaster similar to those which occasionally take place in unsprinklered structures. The life loss has been due largely to local flashes or explosions too quick and deadly even for sprinkler action. It is a fact that employees, knowing that a sprinkler system is provided in a building, are not panic-stricken when fire breaks out. This is an important item. If there is a question of life hazard from fire in a structure in which many persons are employed, the sprinkler system is generally the best solution.

46. Under some conditions where certain types of chemicals are present, as, for example, metallic sodium, sprinklers are an element of danger, as also is the presence of hose lines that may be used improperly.

FIRE BRIGADES.

47. Previous sections have called attention to accident hazards to which a private brigade may be exposed by bad housekeeping, poor illumination, badly placed hydrants, bursting of hose, loss of control of nozzles, dangerously located valves, and defective chemical engines or extinguishers. Particular attention is called to the risks incurred in making use of portable or permanent ladders and to the dangers of working on roofs of buildings from which men might fall. A brigade should be allowed to undertake dangerous work only after it is fairly well trained, and the subject of personal safety should always be before the men. Safety should not be sacrificed to excessive speed at time of drills.

HOME HAZARDS.

48. A large percentage of all fires take place in habitations of various types, and approximately two thirds of the life loss from fires occurs in homes, almost altogether among women and children. The relation of accident prevention to fire prevention is particularly close here.

APPROVED DEVICES.

49. For a number of years Underwriters' Laboratories has been examining, testing, and passing on appliances purely from an accident prevention standpoint, or from a combined fire and accident prevention one. A List of Appliances Inspected for Accident Hazards is published annually. An astonishingly large field has been covered, including, for example, anti-slip materials, automobiles and automotive appliances, boiler, electrical, and elevator equipment, kilns, gases and gas appliances, goggles, guard materials, ladders, and window frames.

ORGANIZED FIRE PROTECTION.

50. The modern safety movement has demonstrated the possibility of really educating the rank and file workman and getting him to be more careful, through the medium of workmen's inspection committees, bulletin boards, and other educational stunts, such as special campaigns. There is a lesson here for the fire protection engineer, because many fire protection elements such as good housekeeping, proper use of matches, etc. are chiefly matters of personal carefulness. In the plant where there is a safety organization it should be used as a vehicle for fire prevention instruction and in a plant where there is no safety organization, one may well be created for the purpose of getting across both the fire prevention and accident prevention ideas.

CHAPTER 4

NATIONAL FIRE PROTECTION ASSOCIATION

BY FRANKLIN H. WENTWORTH *

1. The National Fire Protection Association has two functions. One is to formulate standards under guidance of which the fire waste may be checked; the other is to educate the people in the observance of those standards and point out the economic penalties for ignoring them.

2. Its objects and the qualifications for membership are indicated by the following extracts from its "Articles of Association":

3. Article 2.—The objects of this Association shall be to promote the science and improve the methods of fire protection and prevention; to obtain and circulate information on these subjects and to secure the cooperation of its members in establishing proper safeguards against loss of life and property by fire.

4. Article 3.—Membership shall consist of (a) Members, (b) Associate, (c) Honorary. It is understood that through membership none is pledged to any course of action.

a—Members.—National institutes, societies and associations interested in the protection of life and property against loss by fire, state associations whose principal object is the reduction of fire waste, insurance boards and insurance associations having primary jurisdiction, shall be eligible for membership. Annual dues shall be $60. Members shall have six votes in the affairs of the Association and shall be entitled to four copies of all publications regularly distributed to members.

b—Associate Members.—National, state, and municipal departments and bureaus, state and municipal associations, boards of trade, chambers of commerce, firms, corporations, libraries, and individuals shall be eligible for associate membership. Annual dues shall be $10. Associate members shall have a vote in the affairs of the Association and be entitled to receive one copy of all publications regularly distributed to members.

5. The Association meets annually in a three days' convention at which reports on the various standards are presented by its committees of experts and discussed by the convention before adoption. The proceedings of the annual convention are stenographically reported and issued in printed form so that all members may study the reports and the discussions thereon at their leisure. The progress of the world in science, invention, and the industrial arts makes constant revision of these standards imperative. The Association was organized in 1896, and hence for nearly thirty years has been compiling and revising these standards, which are now the generally recognized guide and authority and which are officially adopted by the National Board of Fire Underwriters and all other organizations interested in fire protection or prevention.

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* Secretary and Treasurer of the National Fire Protection Association.

6. Each member is usually represented at the conventions by its authorized engineer.

7. This work of compiling and revising standards covering explosives, gases, oils, electric wiring, and all fire appliances, must continue indefinitely. It is a work for experts and demands the service of those members having technical education.

8. The character of these standards is indicated by the following list:

Acetylene Gas Machines, Oxy-Acetylene Heating and Welding Apparatus and Storage of Calcium Carbide.
Gasoline Vapor Gas Lighting Machines, Lamps, and Systems.
Blower Systems for Heating and Ventilating, Stock and Refuse Conveying.
Dip Tanks.
Electric Wiring and Apparatus (National Electrical Code).
Electrical Fittings, List of Approved.
Fire Brigades, Private.
Fire Pumps, Steam.
Fire Pumps, Rotary and Centrifugal, and Electrical and Gasoline Engine Driving of Fire Pumps.
First Aid Fire Appliances, Installation, maintenance and use of.
Oil Burning Equipments.
City Gas, Installation, Maintenance and Use of Piping and Fittings.
Gas Shut-off Valves.
Hazardous Liquids, Containers for Storing and Handling.
Hose Houses for mill yards, construction and equipment.
Internal Combustion Engines (gas, gasoline, kerosene, fuel oil) and Coal Gas Producers (pressure and suction systems).
Lightning, Suggestions for protection against.
Marine Fire Hazards.
Municipal Fire Alarm Systems.
Nitro-celluose Motion Picture Films (storage and handling)
Pyroxylin Plastic, Storage and Sale of, in other than plants manufactur-articles therefrom.
Pyroxylin Plastic, Storage, Handling, and Use of in factories making ing articles therefrom.
Protection of Openings in Walls and Partitions.
Signaling Systems used for the transmission of signals affecting the fire hazard.
Roof Openings, Cornices and Gutters.
Sprinkler Equipments, automatic and open systems.
Steam Pump Governors and Auxiliary Pumps.
Tanks (gravity and pressure), Concrete Reservoirs and Valve Pits.
Vaults.
Standpipe and Hose Systems.
Mill (slow-burning) Building Construction, including Scuppers.
Valves, Controlling Water Supplies for Fire Protection.

9. The Association distributes copies of each new edition of the above pamphlets to its members as issued and furnishes the same to the public on application.

10. Besides the hundred-odd principal national institutes, societies, associations, and underwriting boards and bureaus of the United States and Canada which constitute the membership, the Association has now nearly 4,000 associate members, many of whom serve upon important committees and all of whom may share in the Association's great work of public education. The Association takes an important part in the observance of **Fire Prevention Day** on October 9th **each year.**

11. The Association's literature is prepared with the object of educating the layman in fire prevention. Although based upon expert knowledge, it is put into popular form so that anyone is enabled to educate himself to protect his own premises and give advice to his neighbor.

12. The Association's inspection manual, " Field Practice," is the standard inspector's guide for use in his daily work.

The Quarterly magazine of the Association is unique in its special articles on fire hazards, fire protection and prevention, and the economic effects of the fire waste. Its editorial matter is clearly and forcefully written, and its carefully edited department of fire records is indispensable to those who are studying fire causes and effects in specific properties. In the Quarterly are described all the important fires occurring in the United States and Canada, with special reference to their origin, their extent, and the manner of their extinguishment. By a special method of cataloging, statistical records are so kept as to permit the publication in every issue of fire statistics on some special class of factory or occupancy, showing how the majority of such fires start and how in the cases given they were extinguished.

13. Special studies are made of the effect of fire on concrete and other buildings of fire-resistive construction. Unique bulletins are regularly issued covering the hazards of Christmas trees and decorations and Independence Day celebrations; and during each year many individual papers and reports on specific topics are sent to members, besides copies of all the Association s standards as soon as they are complete and published. The office correspondence of the Association is voluminous, as any information in its files accumulated during its life of nearly thirty years is gladly furnished its members on application.

14. The office of the Association in Boston, Mass., is the source of, or clearing house for, all that is authoritative on the subjects of the fire waste, fire protection and fire prevention; and its members are privileged to submit at all times their individual problems for solution. The monthly News-letter keeps members abreast of all new developments in fire prevention matters.

15. The Association's associate membership is composed of architects, builders, merchants, manufacturers, warehousemen, engineers, fire marshals, fire wardens, fire chiefs, electricians, credit men, bankers, insurance agents and inspectors, Boards of Trade, Chambers of Commerce, Public Libraries, and many other organizations, individuals, firms, and corporations.

16. No admission fee is charged for membership. The Quarterly magazine, the published standards, all special bulletins, and other valuable engineering and popular literature issued during the year are supplied to members for ten dollars ($10) per year dues. There is no other expense. The membership year begins with the date of the member's election.

17. Any individual, firm, corporation, or society is eligible to membership.

18. The office of the National Fire Protection Association is at 40 Central Street, Boston, Mass., and the secretary will promptly send sample publications to anyone wishing to know of the work of the Association or who may desire to co-operate with it as a member.

CHAPTER 5

NATIONAL BOARD OF FIRE UNDERWRITERS

By WILBUR E. MALLALIEU *

1. The National Board of Fire Underwriters, an organization in which 180 of the leading fire insurance companies are represented by their executive officers, was organized in 1866. Its headquarters are located at 76 William Street, New York, with branch offices in Chicago and San Francisco.

2. Organized in the troublous period following the Civil War when unlimited rate competition and a rapidly rising fire ratio were threatening the solvency of American fire insurance, it sought to restore stability through a rigorous control of rates. At first these efforts met with considerable success, and to them is largely due the fact that so many companies were able to survive the double blow of the Chicago and Boston conflagrations in 1871 and 1872.

3. However, friction resulted among the companies to such an extent that it was finally found necessary to abandon rate control. This step was taken in 1877, since which date the National Board has had nothing to do with fixing rates. Eleven years later it likewise abandoned jurisdiction over commissions paid to insurance agents and brokers.

4. With this final relinquishment of legislative functions the organization entered upon a new phase of its history and began rapidly to develop into a great service institution—to its members and to the public. In both directions its work has assumed large proportions and its influence has become far-reaching and constructive.

5. The present activity is essentially one of Committees, under the general supervision of the Executive Committee and the direction of the General Manager and his staff. The more important committees are as follows:

6. **The Committee on Laws,** which makes a special study of the legal, legislative, and administrative phases of the relations of fire insurance and the public.

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* General Manager of The National Board of Fire Underwriters.

7. The Committee on Incendiarism and Arson is prosecuting the despicable crime of arson more vigorously and upon a larger scale than ever before, but it no longer offers a reward to those furnishing information. This Committee has branch offices both in Chicago and San Francisco.

8. The Committee on Statistics and Origin of Fires which goes deeply into the study of a vital phase of underwriting knowledge.

9. The Committee on Fire Prevention and Engineering Standards has been for many years the country's strongest influence for the lessening of public fire hazard. This Committee, at large expense, maintains parties of field engineers that are constantly engaged in inspecting water supply, fire department equipment and efficiency, alarm systems, special hazards, etc., in the large cities of the United States. The Committee's particular attention is devoted to the proper protection of congested value districts and the removal of conflagration hazards. Its recommendations have led to extensive improvements in many cities. This Committee is the special intermediary between the Executive Committee and the Underwriters' Laboratories of the National Board.

10. The Committee on Construction of Buildings, which prepares and promulgates building codes and exerts a powerful influence in improving the standard of building construction throughout the country.

11. The Committee on Clauses and Forms, which makes a study of the complicated clause and form requirements of fire insurance policies. Its suggestions are sent out in the form of recommendations and are never mandatory upon the local underwriting associations.

12. The Committee on Adjustments, which maintains emergency adjustment cabinets and is prepared to systematize and facilitate the rapid adjustment of great conflagrations. Augusta, Ga., Paris, Tex., and Astoria, Ore., are recent cases in which notable service was rendered.

13. The Actuarial Bureau Committee, which is engaged in the vast work of recording, tabulating, and interpreting the entire fire loss of the United States for the purpose of ascertaining the relative hazards attached to classes of risks, conditions of localities, etc., etc. This Bureau, with a large force, receives and studies the particulars of the large majority of fires in the country. Incidentally, it is proving an important check upon the operations of incendiaries.

14. The Committee on Public Relations was organized in 1916 to supplement the technical work of other committees by means of educational activities. It has prepared and distributed a great deal of widely circulated printed matter, including the school manual "Safeguarding the Home Against Fire" and "Safeguarding America Against Fire," the latter being a monthly illustrated bulletin of eight pages, which is sent to a mailing list of almost 100,000, most of the recipients being local agents. During the War, the Committee issued several valuable pamphlets, including "Safeguarding Industry," which was prepared for the Council of National Defense, and "Safeguarding Grain in Storage Against Fire," prepared for the U. S. Food Administration, and sent to all distributors and handlers of grain in order to aid in the protection of food stuffs from destruction by fire. The shippers and handlers of cotton were supplied with a booklet entitled "Safeguarding Cotton Against Fire." This committee is one of the active forces behind Fire Prevention Week each year, and has been instrumental in enlarging the national interest in the observance of this occasion.

15. The above includes the chief activities of the National Board of Fire Underwriters. In general, it may be said that it is devoted to the furtherance of fire prevention, just laws, and accurate knowledge. It possesses no legislative powers.

16. The recent history of the National Board has been one of steadily progressing influence, until today it is unquestionably one of the greatest constructive forces in the United States. It has inaugurated and largely sustained, although at private expense, the fire prevention movement that is now finding expression throughout the country—both in the matter of public improvements and of popular education. Its influence upon the more technical side of fire insurance has been in the direction of sound practices, based upon exact information and carried out in a spirit of the broadest equity.

17. It is generally recognized that the National Board has been a leader in bringing about a better understanding between big business and the public.

CHAPTER 6

UNDERWRITERS' LABORATORIES

By **WILLIAM H. MERRILL** *

1. Underwriters' Laboratories is for service—not profit.

2. Its chief financial support has been received from the National Board of Fire Underwriters, under whose general direction the work is carried on.

3. The object of Underwriters' Laboratories is to bring to the user the best obtainable opinion on the merits of appliances, devices, machines, and materials bearing on fire hazards and accident dangers.

4. The work is undertaken as one means of reducing the enormous and disproportionate loss of life and property by fire and the number of accidents in America.

5. Summaries of the Laboratories' reports are promulgated on printed cards filed according to classifications, and cabinets containing these cards are maintained at the offices of the principal Boards of Underwriters and Inspection Bureaus in the United States, at many of the general offices of insurance companies, by some insurance firms, certain federal, state, and municipal departments, and at the local offices of the Laboratories in larger cities. Much of the information is also freely distributed by means of Lists of Manufacturers of Inspected Mechanical Appliances, of Electrical Appliances, of Automotive Appliances, of Burglary Protection Appliances, and of Appliances Inspected for Accident Hazards.

6. The results of the work in many classes of appliances are effectively made known directly to building owners, architects, users, and all other persons interested, by means of the Laboratories' Label Service, under which goods are inspected at factories by Laboratories' engineers and stamps or labels attached to such portion of the output as is found constructed in accordance with standard requirements; and, in addition, by systematic supplementary examinations and tests at the Laboratories of samples of labeled goods purchased in the open market or received from inspectors and users, thus serving to countercheck the efficiency of the factory inspection work and to determine the service value of the product.

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* President of the Underwriters' Laboratories.

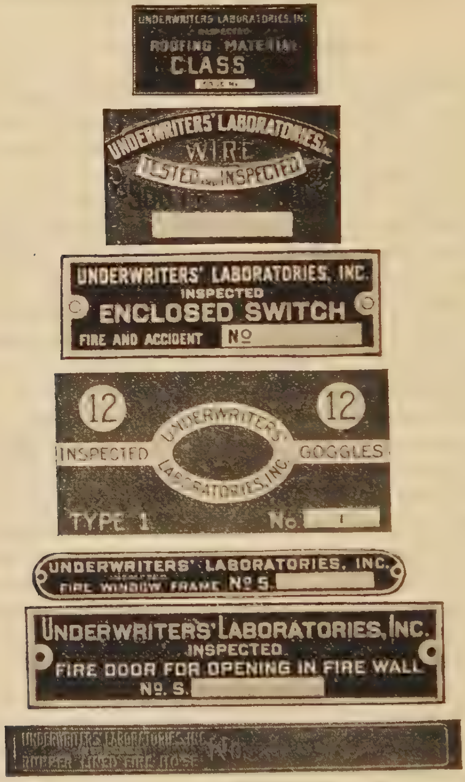

UNDERWRITERS LABORATORIES, INC.
INSPECTED
ROOFING MATERIAL
CLASS
UNDERWRITERS' LABORATORIES INC.
WIRE
TESTED AND INSPECTED
UNDERWRITERS' LABORATORIES, INC.
INSPECTED
ENCLOSED SWITCH
FIRE AND ACCIDENT
NO
12
12
UNDERWRITERS' LABORATORIES, INC.
INSPECTED
GOGGLES
TYPE 1
No.
UNDERWRITERS' LABORATORIES, INC.
FIRE WINDOW FRAME
NO. S.
UNDERWRITERS' LABORATORIES, INC.
INSPECTED
FIRE DOOR FOR OPENING IN FIRE WALL
NO. S.
UNDERWRITERS' LABORATORIES, INC.
RUBBER LINED FIRE HOSE

FIG. 1. EXAMPLES OF LABELS AFFIXED BY UNDERWRITERS' LABORATORIES

Over 130 offices and agencies are maintained throughout the United States and Canada for handling the inspection and Label Service. Fig. 1 illustrates typical labels.

7. For a number of industries this service now includes inspection of the product at factories, check tests on materials purchased in the open market, service value determinations by retests of samples which have been in practical use, and schedule estimates, showing comparative demerits noted on products. These elaborations are working to the decided advantage of all concerned and are possible only under the label service. The Underwriters' Laboratories of Canada handles the work in the Dominion and the Fire Offices' Committee is the representative in Great Britain. Over six hundred million (600,000,000) labels were utilized on products during the year ending December 31, 1922.

8. There exist permanent arrangements between Underwriters' Laboratories and the Bureau of Standards of the Department of Commerce of the Federal Government, and between Underwriters' Laboratories and the Bureau of Mines of the Department of the Interior of the Federal Government, whereby in the event of a fixed difference of opinion on a technical matter between the Underwriters' Laboratories and any of its clients the question at issue may be submitted to either Bureau for decision.

9. The various departments making investigations and tests are the Protection, Hydraulic, Gases and Oils, Chemical, Electrical, Casualty, Automotive, Burglary Protection, Aviation, and Label Service. Their recommendations are passed upon by the council having authority and favorable action is necessary before listing is completed. These bodies which consist of from eight to forty-five members, are the Fire Council, Electrical Council, Casualty Council, Automobile Council, and Burglary Protection Council.

10. A large addition to the main plant and office at 207 East Ohio Street, Chicago, has been recently made and another building to accommodate the steadily increasing demands is being planned. The New York office and testing station has also recently moved into larger quarters in its own building at 109 Leonard Street.

CHAPTER 7

COMMON FIRE CAUSES

1. Behind every fire loss there is a cause, and obviously fire prevention is of paramount importance. Common fire causes underlie virtually the entire fire loss; even in special hazard industries (see Chap. 8) common causes produce most of the losses.

2. In this edition of the Handbook, it is possible for the first time to present in condensed form the result of the nation-wide analysis of fire losses which the National Board of Fire Underwriters is making through its Actuarial Bureau. Loss reports from the large majority of insurance organizations have been gathered and tabulated since January 1, 1915. For the first time in history, a nation knows its loss causes and costs, the distribution by sections of the country, by states, and by cities, the effect of different types of construction and public and private fire protection, and other factors of interest from the prevention and insurance standpoints. The table on page 30 warrants careful study. It drives home the reckless, almost criminal, disregard of a large portion of the American people for property and life so far as fire is concerned.

Exposure losses (including conflagrations—a fire involving loss of one million dollars or more) account for 17.40% of total loss. Unknown cause losses (33.07% of the total), if the facts were known, would probably show a distribution of causes very much like the 66.93% about which there is definite data. Of the known causes, losses are classed 52.77% "strictly preventable" and 47.23% "partly preventable." These figures confirm very closely the long-maintained position that fully 75% of all fire outbreak can be prevented by the exercise of care and the safeguarding of easily protected hazards.

3. While it is possible to debate whether certain causes of fire in the table belong in one general division or the other, and while the relative of dangers for the nation as a whole will not apply in many specific properties, there is no argument that this table indicates the directions in which particular emphasis should be applied. In studying this chapter on Common Fire Causes, the reader should frequently refer to this table. All of the listed fire causes are discussed in this chapter, except that exposure fires are treated in Chapters 10, 11, 13, 14, 29, 34, and 39, and incendiarism in Chap. 35.

4. The main divisions of the chapter are:

a—Lighting.
b—Power Generation.
c—Power Transmission.
d—Heating.
e—Housekeeping.
f—Lockers and Cupboards.
g—Blower Systems.
h—Oils and Paints.
i—Gasolene and Other Inflammable Liquids.
j—Spontaneous Combustion.
k—Explosion Hazards.
l—Film Handling and Storage.
m—Matches.
n—Smoking.
o—Locomotive Sparks.
p—Lightning.

5. For a condensed list of the topics covered, see Table of Contents, and Topical List of Fire Causes, pages 125 to 133.

LIGHTING.

SUNLIGHT

6 The sun is a not inconsiderable fire hazard. Familiar conditions under which it causes fire are:

a—Shining through glass paper weights and similar objects.
b—Shining through fish bowls, water bottles, laboratory flasks, etc., that act as a burning glass.
c—Setting fire to window curtains by virtue of lenses formed by bubbles in window glass.

d—Reflecting from concave mirrors, as under microscopes.

e—Contributing to spontaneous combustion in coal, oily waste, and similar materials.

7. Also, when buildings are shut up tightly over the week-end, the sun quite frequently sets off sprinklers under skylights or in attic spaces and causes considerable water damage.

AMERICAN FIRE LOSSES FOR FIVE YEARS

1916–1920 Inclusive

Compiled by National Board of Fire Underwriters through its Actuarial Bureau

Note: Figures based on 3,300,000 loss reports and approximately 1,500,000 fires. To allow for unreported fires and uninsured losses, fully 25% must be added to the figures appearing in the tabulation.

All figures in thousands, three ciphers omitted.

Item. No.	Cause of Fire	Total 5 Year Losses	Average Annual Losses	Rank Known Causes	Percent Known Causes	Percent All Causes
	Strictly Preventable					
1	Defective chimneys and flues	61,976	12,395	4	9.35	
2	Fireworks, firecrackers, etc.	1,927	385	20	.28	
3	Gas, natural and artificial	12,776	2,555	15	1.93	
4	Hot ashes and coals, open fires	15,564	3,113	14	2.35	
5	Ignition of hot grease, oil, tar, wax, asphalt, etc.	6,262	1,252	17	.94	
6	Matches—Smoking	90,271	18,054	1	13.62	
7	Open Lights	16,287	3,257	13	2.46	
8	Petroleum and its products	33,973	6,795	9	5.12	
9	Rubbish and litter	3,752	750	18	.57	
10	Sparks on roofs	41,667	8,333	7	6.30	
11	Steam and hot water pipes	2,067	413	19	.31	
12	Stoves, furnaces, boilers and their pipes	63,324	12,665	3	9 54	
13	Total—Strictly preventable	349,846	69,967		52.77	26.14
	Partly Preventable					
14	Electricity	85,735	17,147	2	12.92	
15	Explosions	10,342	2,068	16	1.56	
16	Incendiarism	16,628	3,326	12	2.52	
17	Lightning	48,564	9,713	6	7.32	
18	Miscellaneous known causes	25,832	5,166	10	3 92	
19	Sparks from combustion	25,052	5,010	11	3.78	
20	Sparks from machinery	39,673	7,935	8	5.98	
21	Spontaneous combustion	61,193	12,239	5	9.23	
22	Total—Known causes—Partly preventable	313,019	62,604		47.23	23.39
23	Total—All known causes	662,865	132,571		100 00	
24	Exposure (including conflagration)	232,888	46,578			17.40
25	Unknown (probably largely preventable)	442,423	88,485			33.07
26	Grand total	1,338,176	267,634			100.00

8. The remedies are obvious, except in the case of coal piles, where the risk cannot well be avoided.

ELECTRICITY.

9. The treatment of this subject, although found under the heading of "Lighting," applies quite as well to the generating and utilizing of electrical power.

10. As a cause of fire, electricity (not including losses due to lightning) ranks second in the scale as shown in table opposite. The tremendously wide-spread use of electricity in industry, in mining, in transportation, in institutions, and in habitations, and its use for power, light, heating, cooking, signaling, and other purposes, are the reasons for these losses. Were it not for the remarkably good control exercised throughout almost all sections of the country as regards equipment and installation hazards, the losses would be far greater. Nevertheless, there is a decided chance for improvement.

National Electric (Fire) Code.

11. The National Electric (Fire) Code, originally drawn in 1897, combines the joint experience and judgment of all parties interested in the use of electricity, is truly a national standard, and is probably the most extensively used and vigorously enforced code in existence. It is subject to revision each two years as experience warrants.

National Electric Safety Code.

12. With the rapid development of accident prevention in this country, it was felt that there was need of an electrical safety code, and the preparation of this was undertaken and was completed in 1916 by the Bureau of Standards of the United States. Cooperation with the committee having the National Electric Code (now known as the Fire Code) in hand has produced a situation which should avoid conflict between the two codes and cause them effectively to supplement each other.

13. Fundamental life safety principles embodied in the Safety Code include:

a—Isolation of live parts by elevation. The minimum distances are:

Voltage of Parts.	Elevation in Feet.
300 to 750	7.0
750 to 2,500	7.5
2,500 to 7,500	8.0
7,500 to 30,000	9.0
30,000 to 70,000	10.0
70,000 to 100,000	12.0
Over 100,000	14.0

b—Horizontal clearance where work is done about exposed live parts. The minimum distances are:

Voltage of Parts.	Distance in Feet
750 to 7,500	1
7,500 to 30,000	2
30,000 to 50,000	3
50,000 to 70,000	4
70,000 to 100,000	5
Over 100,000	6

c—Barrier protection with asbestos board panels or grounded metal screens.

d—Enclosure of exposed contacts on utilization equipment, such as switches and fuses, resistances, machine connections, and commutators and slip rings. This is always advisable, and is required on voltages in excess of 300.

e—Grounding of neutrals of polyphase systems and of one side of single phase circuits.

f—Grounding of practically every exposed metal container, framework, and base, as, for example, lead sheathed cables, conduits, switchboard frames, all types of transformer cases, generator and motor frames, compensator cases, and enclosing metal screens. See Fig. 3, and page 38.

g—Barring all unauthorized persons from electric generating and substations, switch rooms, and similar sections.

14. The code wisely differentiates in its requirements between buildings and rooms where equipment is in charge of, and only accessible to, experienced persons, and points in industrial plants where persons without knowledge of electric hazards must or can come in contact with circuits and apparatus. The code does not require the best existing practice, but rather good average practice.

List of Electrical Appliances.

15. A List of Inspected Electrical Appliances, which have been examined and approved, is published annually by Underwriters' Laboratories in April, and a supplement to this list is issued each October. Devices and materials upon which tests have been made under the specifications of the National Electrical Code and the standards of Underwriters' Laboratories, and the working of which has been noted in practice, are listed for the convenience of underwriters, electrical inspectors, and engineers who may desire to ascertain readily the names of the manufacturers of devices judged to be designed and manufactured in compliance with these specifications. The section of the National Electric Code relating to the design and construction of appliances is but a partial outline of these specifications. Underwriters' Laboratories has complete standards for electrical fittings, which include the provisions of this code, and, in addition, specifications for the performance under tests and in service, and further details of design and construction. Copies of these standards are obtainable upon request. Some of the articles classified, although not entirely reliable, are the best at present obtainable, and must necessarily be used until more satisfactory devices are put on the market.

16. Care should be taken in all cases to see that the name or the trademark of the manufacturer and the rating in volts or amperes or other proper units are marked on the article purchased, where they may be readily observed after the device is installed. Fittings not so marked should be rejected. Very many classes of electrical fittings are regularly inspected and labeled by Underwriters' Laboratories, as described in Chap. 6, and for such classes of devices labeled products should be called for as labels furnish the most definite and useful evidence of compliance with accepted standards.

Electrical Fire Causes.

17. The fundamental causes of electrical fires are arcs and overheating. The separation of conductors or parts of different potential and the design of equipment to carry safely ordinary loads and even overloads, coupled with automatic protection (fuses or circuit breakers), to open circuits if overload becomes severe enough to be dangerous, enter into the design and installation of all electrical equipment. This should be actively borne in mind in considering electrical fire hazards.

18. Generators have substantially the same fire hazard as motors. Several disastrous fires have occurred because crane blocks or chains have come in contact with generator connections. The lay-out should be such as to avoid having the plane of rotation of the generators in line with the switchboard or other apparatus which might be put out of commission by flying parts.

19. Switchboards of the modern type contain little fire hazard. They are made of incombustible materials, oil switches are covered, and, if of large capacity or high voltage, are commonly put in separate compartments. Wires are generally in conduit, or if not, are covered with flame-proof braids. Closely grouped wires having combustible outer braids are quite frequently wrapped in asbestos and treated with silicate of soda (liquid glass) to afford effective and only moderately expensive protection.

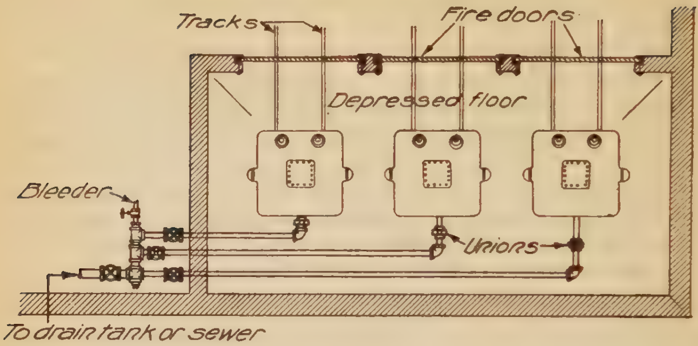
20. Switches are dangerous largely because of poor contacts and connections causing arcs or heating, and because, if exposed and struck by metal, violent short circuits may result.

21. Oil Switches have proved to be a very definite fire cause. The hazard lies chiefly in the oil switch rupturing under heavy overload, as from short circuits on lines, burning oil being scattered, and fire spread thereby. Not only have combustible buildings been destroyed, but incombustible modern structures have been wrecked by such fires. The life hazard has also proved to be a considerable one. Concrete cell construction for switches greatly reduces the fire hazard.

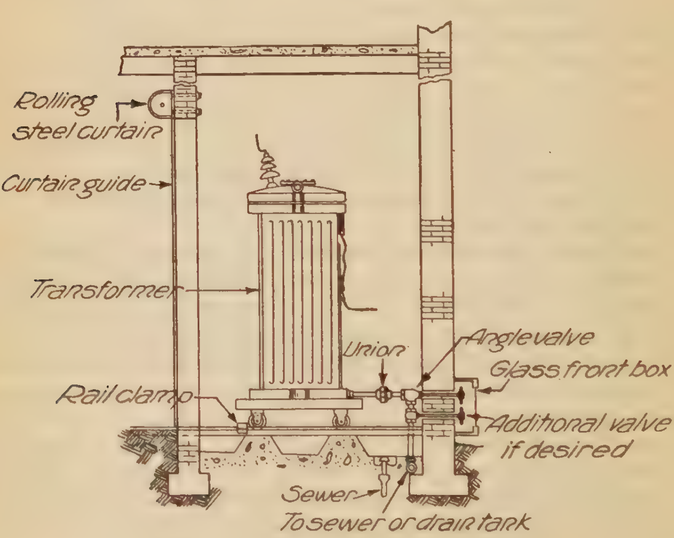
22. **Transformers** containing oil for insulating and cooling purposes have caused some exceedingly serious fires in power houses, substations, and industrial plants, but the danger, considering the number of transformers in use, is not great. Short circuits due to overload, breaking down of insulation, water getting into oil, and to line surges and lightning are the chief fire causes. Oil draw-off connections of ample size, controlled from safe points, are commonly provided where a large number of high tension transformers are located. For large transformers or for sets of smaller ones, separate rooms or cells are advisable. Solid separating fire walls, automatic fire doors on necessary openings, depressed floors or raised sills with areas provided with large trapped drains or sewer connections, are required to restrict spread of fire. See Fig. on the next page.

23. **Lightning Arresters** of the popular aluminum cell type are almost universally used to protect high tension lines. Their cases contain electrolite (not combustible) and oil. Their hazard is probably somewhat greater than that of transformers. Important installations are generally found outside of buildings, but occasionally in separate buildings or in cut off sections. Heavy lightning strokes and overcharging are the chief fire causes.

24. **Fuses and Circuit Breakers** are the safety valves of electrical systems. They are often omitted and frequently abused. Circuit breakers are commonly set unnecessarily ✓high. Fuses are too large, cartridge fuses are refilled or bridged with fuse wire or copper wire of too high carrying power, and occasionally iron pipe, brass tubes, or hay wire will be found in place of fuses. Link fuses if used, generally must be enclosed both for fire and safety reasons. Based on comprehensive tests and extensive field experience, Underwriters' Laboratories in 1919 gave unqualified approval to a maker of cartridge fuses using properly designed renewable elements furnished by the manufacturer. For reasons of safety, convenience, and economy, such fuses are very widely used.



Bank of Transformers in Cell with Draw-off Controlled from Inside of Building



Transformer Draw-off with Emergency Valves Controlled from Outside of Building

FIG. 2. TRANSFORMER DRAW-OFF VALVE PLANS

25. Circuits properly installed in metal or fiber conduit, armored cable, circular loom, or even unprotected against mechanical injury, cause comparatively few fires. The attachments to the circuits constitute the chief fire hazard. Properly soldered and taped joints, adequate supports, protection against mechanical injury where needed, and protection against moisture or fumes are fundamental fire safety features. See Fig. 3 for proper methods of installing circuits and of grounding conduits and apparatus.

26. Temporary Wiring, even if admittedly dangerous in the first place, very frequently becomes permanent. Even temporary wiring should be reasonably safely installed, and it should not be allowed to become permanent unless made fully standard. Dead wiring should be promptly removed, so that it will not be connected up after disuse has permitted deterioration.

27. Motors should be installed in dry locations and where not exposed to corrosive fumes, inflammable gases, dust, or light inflammable material, such as lint. It is frequently practical to drive a machine in a dangerous location by means of a shaft leading to the motor in an outside building or room.

Alternating current motors are less likely to spark than direct current ones, and are consequently safer in practically every location. Motors entirely enclosed, and drawing air from the outside and discharging again to the outside, are often practically safe where open motors would be hazardous.

Exposed contacts on motors are objectionable both from a fire and an accident standpoint.

Proper lubrication with good grade of mineral oil makes for economy, as well as safety. To avoid oil drips, motors can advantageously be placed in heavy drip pans.

28. Incandescent Lamps are frequent causes of electric fires. Even the most efficient lamps use up a large percentage of the current consumed in the formation of heat. In show windows, in clothes closets and lockers, in storage bins, on shelves, and even wrapped up in blankets to act as bed warmers, the incandescent lamp has caused fires. Lamps should be kept clear of combustible material, either by location or by protection with suitable guards. Only incombustible shades should be used. The breaking of incandescent lamps in an atmosphere of gas, as in a garage or a mine, has caused fires and explosions. Portable lamps need heavy rod guard protection, not spring wires directly against lamps, and keyless sockets are generally advisable. See Fig. 4.

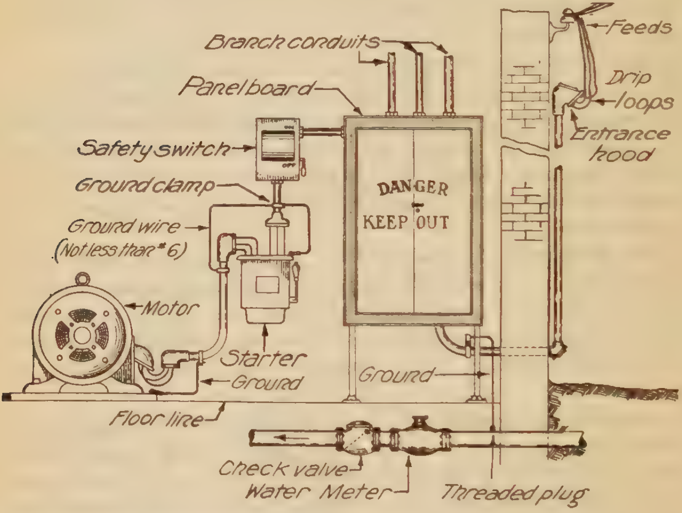
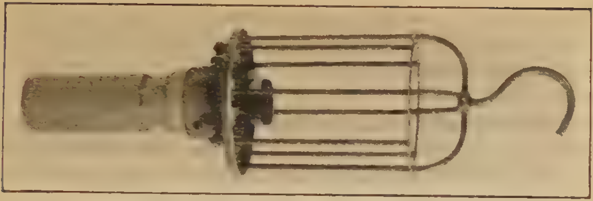


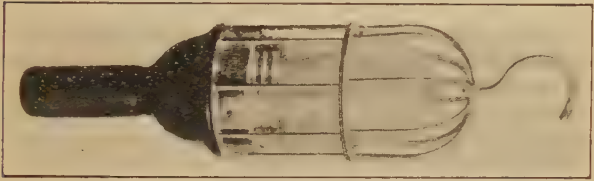
Fig. 3. Methods of Grounding Electrical Apparatus

29. Vapor Proof Fittings, commonly called "marine fittings," are used primarily to protect sockets and lamps against weather, corrosive influences, and contact with inflammable vapors or dusts. The latter function is an important one from a fire prevention standpoint. An incandescent lamp may set fire to dusts deposited directly on it, and arcing due to poor connections or effect of corrosion may ignite vapors. Also occasionally a lamp in breaking may ignite vapors or dusts; the heavy vapor proof outer globe gives substantial protection against such an accident. See Fig. 4.

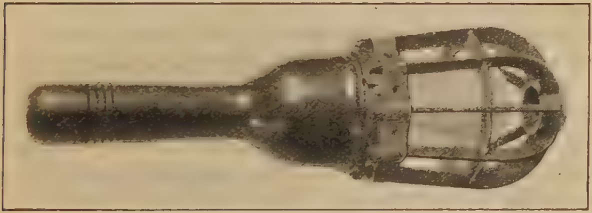
30. Arc Lights of various types may be dangerous owing



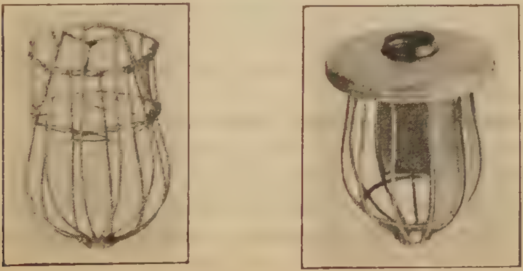
Portable Lamp Guard of Heavy Rod Construction.



Same, with Vapor-Proof Globe.



Portable Lamp Guard Entirely of Fiber to Protect Against Shock.



Pendent Lamp Guards, One with Reflector.

Fig. 4. Guards for Pendant and Portable Lamps

to hot carbon or molten metal falling on inflammable material or because inflammable dust or flyings come in contact with the arc. Safety requires wire enclosures for globes to prevent falling glass.

31. Domestic electrical devices have attained a tremendous distribution. Clothes washers, mangles, dish washers, cooking ranges, vacuum cleaners, pressing irons, radiators, electric pads, foot warmers, fans, toasters, grills, percolators, curling irons, and water heaters are among those found. The average city home has several devices. A number of these devices require comparatively heavy amperage, and often two or more are used at the same time. This puts unexpected strains on circuits and especially on bracket outlets wired for a single lamp. It results in amateur extensions and in overfusing of circuits. It introduces additional portable cords.

32. Electric pressing irons are the greatest electrical hazard, almost half of all electrical fires being attributed to them. Essential safeguards are a circuit heavy enough to carry the necessary current, a pilot light to show when current is on, and a metal bracket or a metal shelf, permanently set well away from and attached to a wall or partition convenient to the ironing place. Ordinary stands leave much to be desired, should current be left on for a long time. The ideal iron is one which by thermostat control prevents any dangerous temperature being attained. Such an iron is now on the market.

33. Electric Soldering Irons are fairly popular, and are often essential if soldering must be done in the presence of inflammable vapors or liquids. Good cords, pilot lights at work benches, and safe supports for irons when not in use are important.

34. Portable and pendent cords are a common cause of fire. Dragging them over floors or apparatus, tying, wiring, or nailing them aside, and drying out of insulation make for considerable risk. The electric lay-out should be such as to require the minimum of **pendent cords,** and where employed they should be properly placed and have shortest possible drops. Similarly, a good lay-out will reduce the use of **port-**

able cords to a minimum. For portable cords an adequate number of conveniently located outlets will reduce lengths of cords and cut down fire risk. Only approved heavy duty portable cords should be used. All cords should be regularly examined, and replaced as soon as they show injury, dryness, or appreciable wear. The life risk, from handling defective portable cords in boilers where grounds are perfect, is considerable. 28 volt circuits have been used for boiler room lighting or for extension cord circuits. See Fig. 4 for several types of lamp guards.

35. Signaling circuits, ordinarily run inside of buildings without the safeguards accorded lighting systems, must be protected, both for life and property safety, at all incoming points against possible crosses with higher tension wires and against lightning. Inside of buildings, signalling circuits should obviously be kept clear of higher voltage conductors. Special protectors of several designs are available, involving the use of a direct well-connected ground wire.

36. Radio and wireless equipment is now so widely used that special regulations are included in the National Electric Code. Fire hazard comes largely from lightning, higher tension crosses, and from careless or ignorant wiring in connection with the apparatus itself. A ground switch connecting the aerial with a good ground, closed when apparatus is not in use, is a standard provision.

37. Static electricity undoubtedly is responsible for a considerable portion of the heavy losses attributed to sparks from machinery, the eighth most serious cause of fire. See table, page 30. In industries where inflammable dust, flyings, and vapors are present the hazard is acute. See page 106, on dusts. Static may be produced by friction of two unlike substances, whether solid, liquid, or gaseous. Everyone is familiar with static produced by belts or coating machines, but that liquid flowing, as gasolene through a rubber hose, solids "flowing," as smokeless powder, or a cloud of blown dust will build up a static charge is not so generally appreciated.

The friction of the wind on particles of water in a mass of clouds has been attributed as being the cause of lightning. Prevention measures include:

a—Preventing the formation of the charge by changing equipment, as, for instance, chain drive instead of belt drive, or neutralizing the charge as formed, as is customary on printing presses.

b—Preventing a dangerous accumulation of charge, by grounding pulleys and shafts, use of combs placed for best results about 12″ from points where belts leave pulley, ground wires placed parallel to belts closely on both sides, use of half glycerine and half water as a belt dressing, and other methods similar in principle.

c—Grounding very thoroughly machinery or equipment through which powder or finely divided material passes.

d—Use of grounded screens near cloth screens through which dust passes.

e—Grounding buildings, tanks, pipe lines, tank wagons, and nozzles on filling hose lines where inflammable liquids are handled. Care must be exercised to avoid a spark when oil lines are disconnected.

f—Moistening the air, for static is worst in dry weather; in fact under conditions of high humidity it can seldom if ever be produced.

GASES.

Natural and Artifical.

38. While the data following applies particularly to gas not manufactured on the premises, the principles may also apply to gasolene gas or other private gas systems. Also these items frequently are applicable to industrial as well as lighting problems. The National Board Regulations for the Installation, Maintenance, and Use of Piping and Fittings for City Gas are the product of co-operative effort of all national organizations interested, are comprehensive, and warrant study.

City, Town, or Retort.

39. It is evident that the chief hazard of gas lighting comes either from the gas jets themselves or the use of matches. The latter is treated as a hazard by itself under a separate heading. **Movable gas jets** have been the cause of many fires, as they are generally located so that it is possible for them to swing against or under combustible material. Stationary gas fixtures, therefore, are preferable and if movable fixtures are used, suitable stops should be provided. Short brackets on combustible walls are also dangerous.

40. Next to this comes the danger of **combustible material** coming against the gas jet, and this can be partially guarded against by the use of suitable wire globes or guards. These guards should be securely attached and of sufficient strength to withstand ordinary usage. It is most desirable that gas jets be installed away from windows so that curtains cannot blow into them.

41. Fires have sometimes been caused by the **lava tip blowing out** of the gas burner and the obvious remedy is to use a burner so designed that this cannot happen. A number of such burners are on the market.

42. Leaking piping and fixtures are a decided hazard, both to life and property. Obviously, only first class workmanship is advisable, when it comes to installing gas piping. It would seem unnecessary to suggest that gas leaks should not be looked for with a lighted match, and yet such reckless practice is literally a daily cause of explosion.

43. The use of **rubber tubing** in connection with gas consuming devices such as heaters, portable stoves, and table lamps introduces a very decided fire and life risk. Tubing generally is of poor material, rapidly dries and cracks, may be pulled off of the pipe connection at either end by a child, a playful dog, or a person brushing against it. Wherever possible pipe connections should be used. Where tubing must be used, it should be of first class quality, securely attached at both ends, and provided with a shut-off cock only at the pipe end so that there will be no danger of the tubing being left under pressure.

44. Wherever **electric wiring** is located in a building, and there is danger of rubber covered conductors or conduit coming into contact with the gas piping, it is good policy to provide a bridge for the meter, so that no fire may start at this point owing to current seeking a ground. Where passing through walls piping should be cemented in tightly.

45. One of the most important points in connection with larger gas services is to have a readily accessible **shut-off valve** for operation in case of necessity. Some fires have spread rapidly and have become serious because of broken gas piping or melted meter connections, with resulting large flow of gas. One of the following methods of procedure is usually advisable:

a—The National Board Rules specify all service pipes 2″ in diam. and over shall be equipped with a gate valve for shutting off the gas, located outside the building. Shut-off cocks or valves in stop or valve boxes, manholes, or vaults are required.

b—An alternative, especially where tampering is not likely, is to attach an extension stem to the inside valve wheel. See Fig. 5.

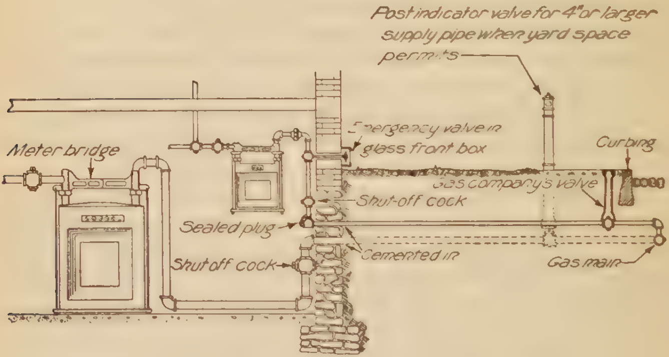

Post indicator valve for 4" or larger supply pipe when yard space permits
Emergency valve in glass front box
Curbing
Meter bridge
Gas company's valve
Shut-off cock
Sealed plug
Cemented in
Gas main
Shut off cock

Fig. 5. Control for Gas Service Connections

c—The use of an automatic form of shut-off valve is inadvisable, because at time of fire continued availability of gas for illuminating purposes may be of real moment.

d—For industrial plants where some gas service connections are very large, indicator posts are recommended, located where safe from falling walls, and carrying signs showing their purpose. See Fig. 5 and also Fig. 61, page 405.

e—On each floor where there is appreciable use of gas, as in an industrial plant, there should be an accessible shut-off valve for quick manipulations.

f—Gas shut-off cocks should operate readily. If neglected they almost always stick tightly.

46. Quarter-in-the-slot meters are a menace to life and property because gas may be cut off by the meter when one or more burners are open. The use of such meters is not advisable.

47. The practice of connecting meters with **lead piping** is somewhat objectionable, and the modern tendency is to provide iron pipe connections. It must be noted, however, that the soldered joints of the meter will melt readily if not more readily than a fairly heavy lead pipe. Large gas meters are often placed on shelves; very large ones can properly be placed outside of important buildings.

48. For list of special hazards of gas manufacturing plants, see page 141.

Gasolene Gas.

49. Gasolene lighting devices have been and are being installed in large numbers in practically all sections of the country. Because they go principally into rural districts, the extent to which they are being used is not generally appreciated.

50. The classifications given in the rules and requirements of the National Board of Fire Underwriters for the "Construction, Intallation, and Use of Gasolene Vapor Gas Lighting Machines, Lamps and Systems" are as follows:

Class "A"—Machines having outside carbureters.

Class "B"—Machines having inside carbureters.

Class "C"—Systems having outside tanks and inside flame-heated generators.

Class "D"—Gasolene vapor lamps.

Class "E"—Systems having inside tanks and inside flame-heated generators.

51. Class "A" Systems—These are by far the safest, introducing practically no more hazard than ordinary city gas.

52. Carbureter or supply tank should be located outside and underground at least 30 ft. away from the building, and the top of carbureter should be below the level of the lowest pipe in the building, and prefrably below the level of the basement floor. Pipes from carbureter to building must have incline toward the carbureter. Where there is much water in the ground, carbureters must be protected against floating out of position.

53. Mixers should be entirely automatic and self-governing, in order to produce a uniform quality of gas. The air pipe from pump must be carried at least 24″ higher than the top of the filler pipe on carbureters to prevent gasolene from being forced into the building.

54. Class "B" Systems—The introduction of a carbureter into a building increases the fire hazard, and yet the record of these devices has not been bad. They are used chiefly in connection with industrial plant systems.

55. Class "C" Systems—In these systems, the gasolene is conveyed in liquid form through small copper tubes, either to the individual lamps, where it is vaporized, mixed with air and burned, or to a common generator, where the gas is made and discharged through pipes to the lamps.

56. Such systems must be considered as more dangerous than the gasolene systems where the carbureters are located outside, and the gas only is admitted to the building.

57. For any gasolene gas-producing or lighting device, it is essential that the installation rules of the National Board be closely followed and that only such systems as are permitted be purchased. Furthermore, the work should be done by reputable parties familiar with this character of equipment.

58. Gasolene Flares—The use of the gravity gasolene lamp, commonly found in circuses and street fairs and on construction work, is accompanied by fire hazard. The lamps are subject to mechanical injury, burning gasolene may drip onto inflammable material below, and there is nothing to keep inflammable material from coming into contact with the lamps. Both from a fire and an accident standpoint, the lamps are viewed with considerable apprehension.

Calcium Carbide.

59. Calcium Carbide is a hard, opaque, crystalline substance, known is chemistry as CaC_2, in appearance, to the touch, and in the manner in which it fractures, it is not unlike crushed granite. It is produced by fusing carefully selected lime and carbon, at an extremely high temperature, in an electric furnace.

60. Calcium Carbide, itself, is not inflammable; will not burn; can not explode; and is not affected by shock or concussion. It will keep indefinitely, without deterioration, if protected from air or moisture. While calcium carbide is now quite universally recognized as a safe substance to store or transport under proper conditions, its affinity for water and the moisture of the air, which creates Acetylene, introduces a hazard which makes it desirable that certain safeguards shall be observed in the storage and use of this material, as prescribed in the rules of the National Board. It is generally recognized that calcium carbide should be stored above ground, in a dry, well-ventilated place; that apparatus be charged during daylight hours, and without the use of open flame illuminants.

Acetylene Gas.

61. Acetylene (C_2H_2) is an endothermic gas having a wide explosive range. It is non-toxic. Its pungent odor enables leaks to be detected very quickly. Pure acetylene is not explosive at pressures below 15 lbs. per square inch. Acetylene Gas must not be compressed beyond 15 lbs. per square inch except where it is compressed into special cylinders filled with a porous material and a solvent.

62. In many respects acetylene gas is similar to gasolene gas, principally in that the chief danger lies in the use of unpermitted machines and their care and handling. It is desirable that machines be located in heated buildings, preferrably detached, and that such buildings have ample windows and good ventilation.

63. The examination of any source of gas supply with a naked light is ultra-hazardous. Dark basements are objectionable, and any basement is objectionable if furnace or other fires are nearby. With a permitted generator (passed by the Underwriters' Laboratories) and with the system properly piped, installed, and cared for, the hazards of acetylene lighting are not serious.

64. The extent to which acetylene gas is used for lighting purposes is seldom realized. There are over 500,000 installations in all parts of the country. In spite of occasional explosions, the fire record has been good, probably better than that of lamps or candles which acetylene replaces. The brilliant and pleasant light, the cleanliness, and the lack of seriously poisonous qualities are responsible for the popularity of acetylene.

65. An acetylene flare light suitable for contractors, marine signaling, and for illumination at fires has been developed. The light is powerful and has wide spread use. Acetylene compressed into small cylinders is extensively used on automobiles, especially on trucks as an illuminant. Individual generator acetylene table lamps have been manufactured but are now practically obsolete. Acetylene cap lamps are extensively used by miners where gas or dust hazards do not exist.

Oxy-Acetylene Welding Systems.

66. The rapid introduction of oxy-acetylene systems has brought with it certain fire hazards, very moderate on the whole, and, as a result, special rules on Oxy-Acetylene Cutting and Welding Apparatus are included in the Acetylene rules of the National Board of Fire Underwriters. Underwriters' Laboratories have passed low pressure (maximum 1 lb.) portable generators and medium pressure (maximum 15 lb.) stationary generators, as well as regulators and blowpipes. Only permitted apparatus should be purchased and it should be installed and operated as provided by the rules.

67. The ordinary house lighting generator has a gas pressure of about three inches of water, whereas the commercial machines used with oxy-acetylene blow pipes will run up to fifteen pounds. Obviously, a different form of construction is necessary, and there is more mechanical equipment subject to getting out of order. Stationary generators belong in preferably detached buildings, safely heated, well lighted, clean, normally locked, and subject to control of skilled attendant. Pressure tanks, such as are used for railway lighting, are widely used in place of generators, especially for portable sets.

Compressed or Liquid Gases.

68. The following types of compressed or liquid gases are extensively used:

a—Pintsch gas, primarily for railway car lighting.

b—Acetylene gas compressed into cylinders filled with porous material and dissolved in acetone, extensively used for automobile and marine lighting, and for welding and cutting purposes. Maximum pressure should be 250 lbs. at 70° F.

c—Compressed hydrocarbon gases, used for industrial and occasionally for residence heating and lighting purposes. Maximum pressure should be 1500 lbs.

d—Oxygen gas which may explode if carelessly made by the electrolytic process. Reversing of polarity is the chief danger. Following a number of such explosions, Underwriters' Laboratories has undertaken the supervision of manufacturing methods, under which electrolytic oxygen and hydrogen are produced. Liquid air oxygen cannot under any conditions contain oxygen and hydrogen in the same cylinder and it is therefore safer. Oxygen must at all times, from compressor to point of utilization, be kept free of oil or grease if explosion is to be avoided. Oxygen combined with acetylene is used on a very extensive basis for cutting and welding, and oxygen also has considerable medicinal use. Maximum pressure in cylinders should not exceed 2000 lbs. at 70° F.

e—Hydrogen gas used in connection with oxygen for securing high temperatures.

f—Ammonia for refrigeration and chlorine for bleaching and other purposes.

Any pressure tank, particularly when it contains an inflammable liquid or gas, has real possibilities of danger. The essential safety features include:

1. Adequate strength of storage tanks, covering which specifications of the Interstate Commerce Commission exist.
2. Protection of storage tanks, preferably with safety valves, but in any event with fusible plugs to melt at temperature sufficiently low to prevent breakage of tank should it be heated as in fire.
3. Storage of reserve supply of tanks outside of important buildings. Protection against the sun will prevent dangerous rises in temperatures and pressures.
4. Protection of the low pressure side by means of safety valve to prevent excess pressure on service piping and on apparatus.
5. Slow opening of valves, as high temperature or static electricity may be generated by very rapid flow of gas, to prevent combustible gases igniting.

OILS.

Lamps.

69. Portable kerosene oil lamps are in such general use that but little need be said. Such lamps should be of metal (not glass), strongly constructed, and it is to be noted that central draft lamps are not approved. Lamps should be filled by daylight only, kept well filled, be clean, and wicks must be of proper width and thickness, and of ample length. Burners can to advantage be boiled in a soda solution occasionally. When lamps are used for factory lighting they should be supported by suitable metal hangers and proper heat guards provided to protect the hanger and the material overhead. Benzine-burning safety lamps are used in mining operations, although less so than formally. Electric and acetylene lamps have made great headway. Speaking generally, lamps must be considered more hazardous than gas or electricity.

Lanterns.

70. Lanterns should be strongly constructed of metal, with proper guards to protect the chimney. A common fault is the removable bottom for filling which may get loose and drop out. Numerous so-called safety lanterns are on the market, some of which have given good service, especially for watchman's use. Numerous fires have been caused by broken or defective lanterns and the hazard deserves greater attention than it ordinarily receives.

Battery Lamps.

71. There is an increasing tendency to use storage battery lanterns for watchmen wherever inflammable vapor dangers exist. These lamps, while rather heavy, are cheaper to operate than flash lights requiring expensive dry batteries.

Kerosene Pressure Systems.

72. The National Board Rules cover kerosene pressure systems used to supply vapor lamps, stoves, blow torches, and furnaces with oil under considerable pressure. These are regarded as much more hazardous than ordinary kerosene lamps and stoves. They are approximately in the same class for hazards as the Class C gasolene system. See page 46. For kerosene heating systems for dwellings see page 61.

Kerosene Torches.

73. Kerosene torches are commonly used for illumination by trainmen, and occasionally found in car barns and even in dangerous places, such as coal grinding plants. There is no serious objection to an open torch where there is nothing of an inflammable or explosive nature about, but at all other points the use of such torches should be forbidden. They have no place in the equipment of the ordinary plant or property.

POWER GENERATION.

BOILER ROOMS.

74. The hazards of boiler installation come chiefly from explosion, from overheating of chimneys or stacks, with consequent setting fire to buildings, from ignition of floors, partitions, or other woodwork nearby, and in connection with fuels such as coal, oil, wood, shavings, refuse, and sweepings. Specific treatment is hereafter given to spontaneous combustion hazards in coal storage (see pages 53 and 104), fuel oil (see page 55), and pulverized fuel (see page 53).

75. The greatest safety for any boiler installation is secured with a detached building, preferably incombustible. When it adjoins another structure, the boiler room should preferably be of fire resistive construction, cut off with standard fire doors. If boilers must be located in a building, the floor construction over them should be incombustible, even if the rest of the building is not, there should be ample clearance, and neither combustible finish floor nor combustible storage kept immediately over the boiler room, if there is the least possibility of transmitted heat producing a dangerous temperature. Concrete or tile construction both holds and transmits long-continued heat to a dangerous degree. See page 69, para. 141.

76. That no wooden construction should come in contact with or even close to a boiler setting or be involved in ash handling system would seem obvious, and yet such fire hazards are not uncommonly found.

77. Prompt removal of hot ashes makes for efficiency and safety, and it frequently bears on fire prevention.

78. Where refuse or sweepings are burned under boilers they should be burned promptly when received, or, if they must be stored, kept in fire-proof bin or vault cut off from boiler room. See Fig. 10, page 64.

79. Soft coal storage, where fire in it might jeopardize the boiler house or other important buildings, should not be allowed. The piling of coal against wooden side walls is particularly objectionable.

STACKS.

80. An outside stack of brick, concrete, or metal is preferable to one carried through the roof unless the roof is incombustible.

81. Where brick or concrete stacks are carried through wooden roofs, there should preferably be liberal clearance, and not infrequently it is good policy to have the stack construction double with air space. Chimneys in walls, especially where large boilers connect thereto, are a distinct danger unless wooden construction is kept 12″ or more away from flue. Joists set into walls are especially apt to come too close for safety. Combustible finish on the face of chimney is undesirable. Often it is necessary to abandon such chimneys and build new independent safe ones. See page 69.

82. Metal stacks carried through combustible roofs should be safeguarded as shown in Fig. 6. They require firm guying to keep them central in roof opening.

83. Uptakes from boilers should be at least 3 ft. from timbers or other woodwork. If nearer, protection with air cell asbestos board, at least ½″ thick is in order, or removal of combustible construction in danger zone, is advisable. This is generally true where clearance is less than 18″, and even this distance may not be adequate where temperature is high and uptake large.

84. A common cause of fire is sparks from boiler stacks. Where wood is used for fuel, stacks should be provided with spark arresters, or spark chambers or deflectors built into the base of stacks will accomplish the same result. For very important or hazardous locations, as large lumber yards exposed by refuse burning boiler houses, both the deflector chamber and screened top may be advisable.

COAL.

85. Coal storage, especially bituminous, in important structures is generally not wise, partly because it may ignite spontaneously, and partly because, if ignited from any cause, it produces a fire very troublesome to extinguish. Outside storage, or special storage buildings or sheds, or incombustible fuel rooms on the ground level are recommended. See page 104 for spontaneous combustion of coal.

PULVERIZED FUEL.

86. In recent years there has been a rapid development in the burning of pulverized fuel, generally low cost bituminous coal. In plants where it is produced, powdered pitch is also

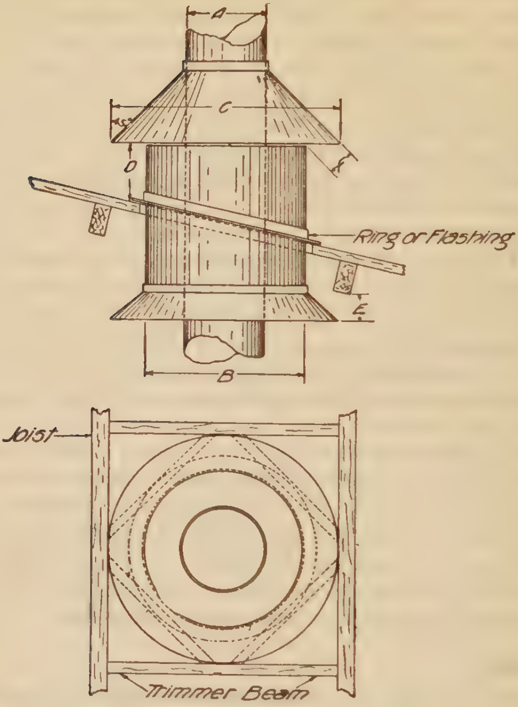


FIG. 6. ARRANGEMENT OF IRON STACK THROUGH WOODEN ROOF.
(Courtesy of Independence Bureau.)

Specifications.—Sheet metal to be at least 18-gage galvanized iron. *B* to be twice *A* except that where *A* is less than 12″ *B* should be 12″ greater than *A*. For wood-burning installation, *B* to be at least 18″ greater than *A*. Maximum difference in diameter to be 4′–0″. *C* to be designed to bring lower edge of umbrella to top of collar. *D* to be at least 12″. *E* to be at least 6″. *F* to be at least ⅜ of *A*.

being burned. For certain forms of kilns and furnaces such fuel is particularly efficient, a proper mixture of pulverized fuel and air developing exceedingly high temperatures capable of close regulation. The systems in use operate in one of three ways:

a—Pulverization at the point of use, where it is blown into furnace.
b—Pulverization at a central point and distribution of fuel to point of use, where it is blown into furnace.
c—Pulverization at central point and distribution of fuel and air through large pipes to points of use.

87. Obviously "a" is the safest and "c" the least safe system. Any pulverized fuel plant warrants careful analysis from a fire and accident prevention standpoint. Crushing, conveying, drying, storing, and pulverizing coal all have inherent hazards, principally the accumulation of dust outside of apparatus and the mixing of this dust with air, its ignition, and resultant flash or explosion. Pulverized coal flows almost like a liquid. There have been numerous explosions, some with serious life loss. Tight apparatus, a design of building and apparatus least likely to permit dust to lodge, freedom from ignition possibilities due to spark or flame, and continuous cleaning up are the best safeguards. Vacuum cleaners have been used for such cleaning.

FUEL OIL.

88. Fuel oil, using the term broadly, is used to an astonishing degree for power generation in navigation, transportation, and industry, and also extensively for heating of large structures. The economic advantages of such fuel have caused the Underwriters to modify their former attitude calling for outside diked or underground storage tanks only, so that the present regulations covering Construction and Installation of Oil Burning Equipment and for the Storage and Use of Oil Fuels used in connection therewith, permit four classes of oil storage, namely:

a—Outside underground storage tanks.
b—Under the building storage tanks.

c—Above ground storage tanks (diked) with outside underground service tanks.

d—Inside the building storage tanks.

89. The order indicates fairly well the relative desirability from the safety standpoint. Oil burning installations should always be taken up specifically with the Underwriters having jurisdiction before equipment is ordered or work begun. Underwriters' Laboratories have passed certain fuel oil engines, oil burners, and auxiliary equipment.

90. The rules recognize two general classes of oil burning systems, namely:

a—With constant attendance and using oil with closed cup test flash point not less than 150° F.

b—Without constant attendance, and oil not less than 100° F. flash point.

91. This virtually means a separation between the heavy, low cost fuel burning systems for power purposes and kerosene burned in dwellings. In the following sections some of the high points of the regulations are presented, no attempt being made to give details, as, for example, metal thicknesses for different tank shapes and capacities. See also Gasolene and other Inflammable Liquids on page 94.

Storage Tank Capacities.

92. Outside Buildings. Allowable capacities under different situations are as follows:

Distance from any important building having floor or pit lower than top of storage tank	Maximum gallons permitted	
	Underground	Above ground
Less than 10′	50,000	750
10′ to 19′ 11″	75,000	1,100
20′ to 24′ 11″	100,000	3,000
25′ to 29′ 11″	150,000	21,000
30′ to 39′ 11″	200,000	31,000
40′ to 49′ 11″	500,000	45,000
50′ to 59′ 11″	Unlimited	80,000

For above ground storage, table continues until at 350′ permitted storage is 2,666,000 gallons.

Between distances of 50 ft. and 175 ft., a 33% increase in capacity is permitted if there is an approved extinguishing system.

Note: Where flash points are lower than specified in par. 90, the storage restrictions are more rigorous. It is always well to consult the underwriters having jurisdiction before installing oil storage of appreciable size.

93. Inside Buildings. The rules permit:

a—With ordinary construction 5000 gallons maximum.
b—With fire-resistive construction 10000 gallons maximum.
c—With any construction, with fully cut off room and sand installation, 50000 gallons maximum in two or more tanks.
d—For dwelling heater types, maximum storage tank capacity 275 gallons, unless buried and no gravity feed possible. Auxiliary supply tank not over 60 gallons, which capacity is part of the 275 gallon limit.

Tank Connections.

The majority of the items called for in the following paragraphs are shown in Figs. 7 and 8 which warrant careful study.

94. Manhole Covers to be fastened securely and not used for fill, vent, or measuring purposes. All tanks to have tight metal tops.

95. Fill Connections to be permanent, filling to be done at point outside any building, and fill pipe trapped by having end in tank turned up.

96. Vents for underground tanks shall be independent from top of each tank, and

a—Adequate for tank size and not less than 1½" in diameter.
b—Through permanently open galvanized pipe terminating outside of building at an accessible point above level of highest fill point.
c—Screened with 40 x 40 non-corrodible wire mesh, as Monel metal.
d—Protected with hood or equivalent against weather.

The Laboratories have passed a combined pressure relief

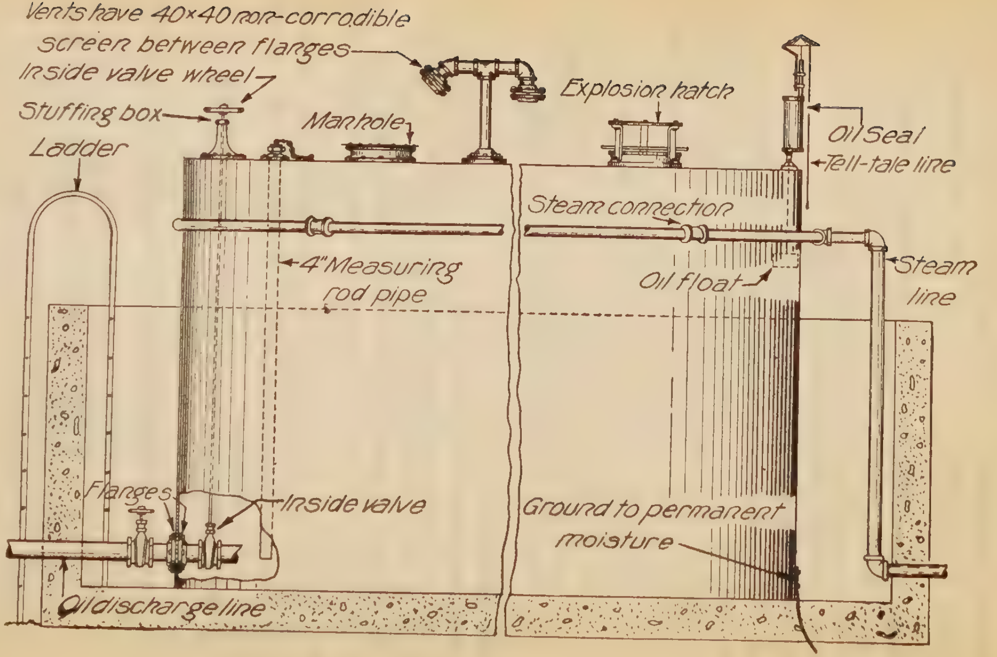


Fig. 7. Oil Storage Tank and Connections
For Details of Oil Sealed Float Indicator, see Fig. 8

and vent fitting, fully protected with screen, for use on storage tanks and tank cars of various types.

97. Vents for above ground tanks to be same as for underground tanks, and in addition having 40 x 40 mesh screen for any other openings which may emit inflammable vapors, and have safety relief (special explosion hatches or weighted manhole covers) of area equal to 1½% of roof area.

98. Test-Well or gauging device shall be installed in such manner as to prevent escape of oil or vapor.

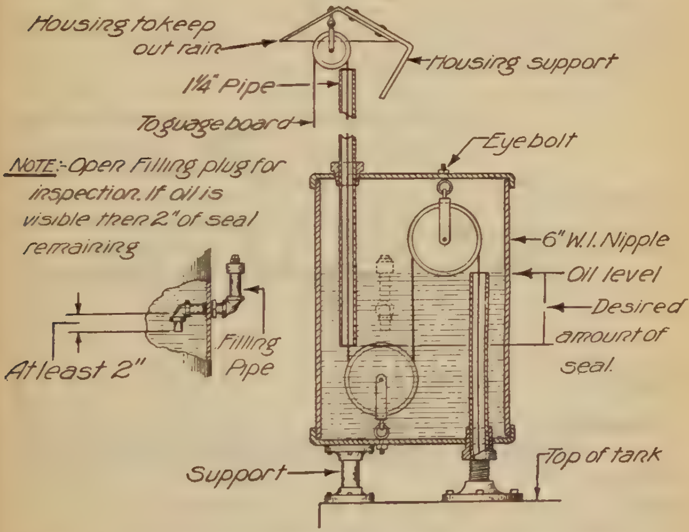


Fig. 8. Oil Sealed Float Indicator for Tanks Containing Inflammable Liquids

Piping and Valves.

99. Piping handling an inflammable liquid under pressure must be of first-class material, carefully installed, firmly supported, and properly maintained. The N. F. P. A. analysis of 102 fuel oil system fires showed 25.5% due to **broken pipes,** and 11.2% due to broken or defective fittings and valves, the two highest causes.

100. Valves are specified generously so as to admit of repair and emergency shut off under virtually any condition that may arise. The use of two valves in series is common practice. See Fig. 2, page 36, and Fig. 7, page 58. Pressure relief in burner supply line shall discharge to storage tank.

101. The use of **automatic shut-off valves** is recommended in oil lines. If a line or fitting breaks, or draft of oil otherwise rises much above the ordinary flow for which an automatic shut-off valve is set, it promptly closes. It can readily be reset, and its capacity is adjustable.

Careless operation of oil valves was responsible for 10.8% of the 102 fires analysed by the N. F. P. A.

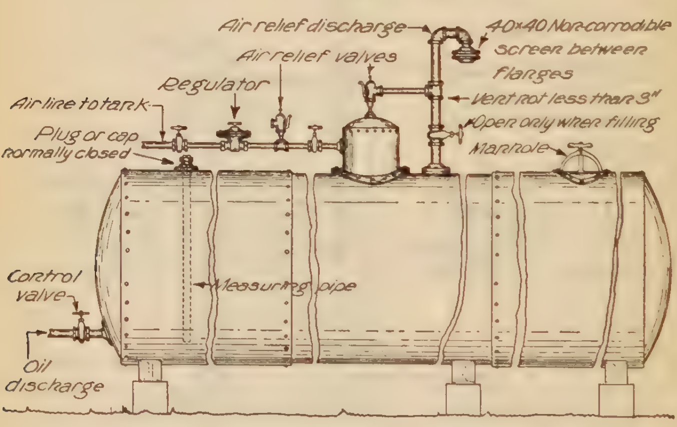


FIG. 9. OIL FEED TANK UNDER AIR PRESSURE
(Not approved for general use)

Heaters, Pumps, and Burners.

102. Heating of oil, necessary in colder climates especially, may be done in storage tanks (to not more than 40° F. below flash point) or in special heaters using steam, water, or approved electrical heater.

103. Pump feed to burners is required for heavy oil systems. Pumps in duplicate, in cut-off room, and preferably always with remote control are specified. See par. 222 for description of the hydraulic system available under certain conditions in lieu of pumps.

104. Burners are varied in design. General requirements are substantial construction, independent supports, and a type of needle valve which will not enlarge the orifice and not capable of being unscrewed and removed during operation.

Air Pressure Systems.

105. See page 97, par. 223 for the fundamental objections to feeding oil to burners or other points of consumption by air pressure on the storage tank. If the air pressure system is installed, safeguards as shown in Fig. 9 should be provided. Automatic shut-off valves are especially important under these conditions.

DOMESTIC HEATING.

106. A more recent development in the burning of **liquid fuel** are equipments designed for heating dwellings and also other buildings requiring total radiation of not appreciably more than 2000 sq. ft. of steam. Any type of boiler or heater can be so equipped, although best results are secured with specially designed furnaces. The fuel shortage during the war gave such heating its first real impetus, but convenience, cleanliness, uniform temperature control, and economy have caused rapid strides in the installation of such systems. Several have been passed by Underwriters' Laboratories.

107. All systems are designed to operate without an attendant, and certain ones are entirely automatic in action. They are designed to use kerosene (legal flash point not less than 100 degrees F.) or certain high-grade distillates of flash point not less than kerosene and which are delivered clean and free from sediment and water.

108. Certain inherent hazards exist where liquid fuel is burned, as set forth below, but a favorable fact is the elimination of the ash hazard and of the storage of kindling wood and paper. Also, serious overheating, a decided hazard where coal or wood is burned, and roof and chimney fire dangers are virtually eliminated with a properly designed burner limited to a certain maximum oil flow per hour.

109. The essential points from a fire prevention standpoint regarding liquid fuel systems are:

a—Auxiliary supply tank to burner not to exceed 60 gallons capacity, and heavy gage, tight metal tank to vent directly to outside, and to have overflow returning to main supply tank. Direct feed to burner is not allowed.

b—Main supply tank to be outside, preferably underground, with top lower than basement floor, and with usual fill and vent connections. See Fig. 7. The so-called hydraulic system can be used to feed fuel to the burner. See par. 222, page 97.

c—Inside feed tank to be filled from main supply tank by means of hand pump or motor driven pump, preferably the former.

d—Burner size and its maximum fuel capacity and air mixture to be established and adjusted to fit the specific furnace, otherwise poor combustion, heavy soot production, overheating of smoke pipe, and general inefficiency may result.

e—Adequate gas pilot flame to be provided, and automatic shut-off of oil flow to result if pilot is extinguished or fails to ignite liquid fuel.

f—Forced draft used to burn liquid fuel. Natural draft systems, used more or less for decades, do not appear to be efficient.

g—Only one automatic burner to be used in any one furnace.

110. While Underwriters' Laboratories have passed certain systems, the local underwriters having jurisdiction must always be consulted regarding the installation of oil tanks both inside and outside.

FIRE EXTINGUISHING.

111. For special provisions for extinguishing fires in oil tanks see page 428.

PORTABLE FORGES OR TORCHES.

112. The use of portable oil burning devices for heating of metal at the job carries with it a considerable danger. In one case, a broken discharge pipe sprayed burning oil on four men, all of whom died of burns. Essential safety features include:

a—Strong and periodically tested pressure tanks.
b—Substantial trucks designed to prevent overturning.
c—Protection of piping (especially oil) against accidental breakage.
d—Relief valves to avoid excessive air pressure.
e—Use of metal piping instead of hose.
f—Adequate valve equipment on air and oil pipes or hose, all at tanks.
g—Automatic shut-off valves on oil feed outlets.
h—Use of devices where construction and contents of buildings do not invite danger.
i—Filling outside of important buildings.

113. Locomotive tire heating torches, employing kerosene and even gasolene, have been found in use. All such apparatus needs frequent and careful inspection, and should not be used unless in perfect repair.

SHAVING VAULTS.

114. Such vaults are found almost universally in plants where woodworking is carried on and shavings are burned under boilers. Fig. 10 shows a desirable type of vault, and has the following principal features:

a—Fire-resistive construction with vents in roof to relieve dust explosions.
b—Located not too close to boiler fire doors and not in line with them, because back draft might carry fire out of boiler setting, and cut-off from boiler room by standard fire door.
c—Provided with cyclone to release air produced by blower system, and to permit shavings to drop quietly into vault.
d—Facilities for feeding fuel directly to boiler or to vault, as preferred. Such direct feed not shown in Fig. 7.
e—Gravity check valve in fuel pipe to boilers to reduce likelihood of fire flashing into vault.

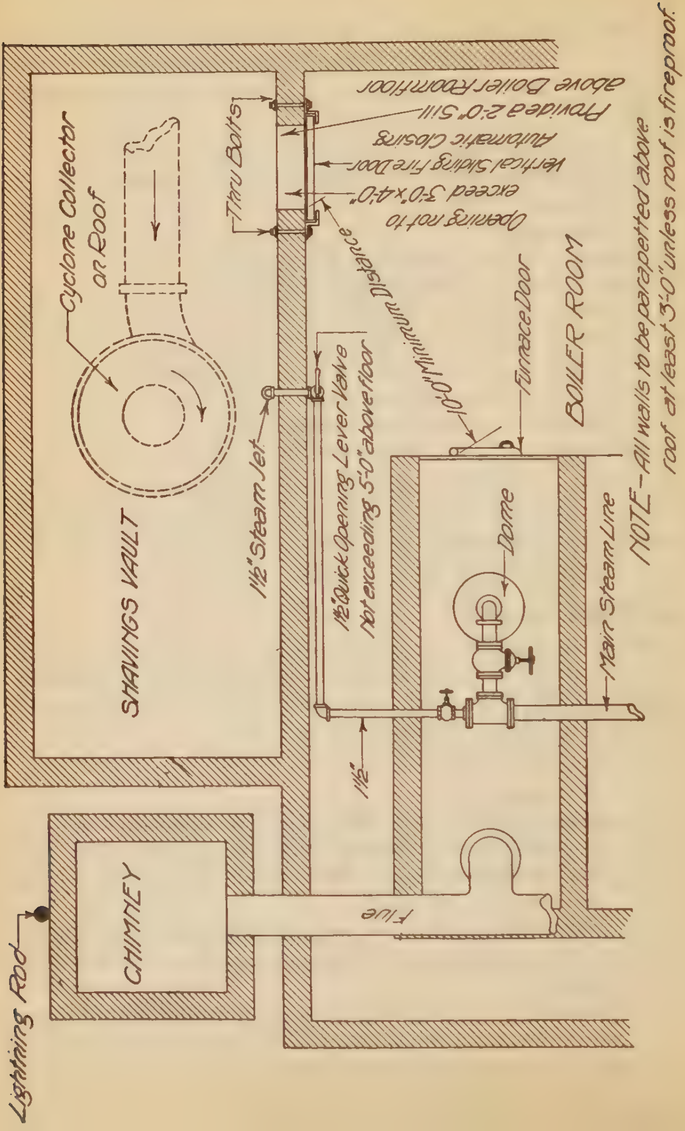

Cyclone Collector on Roof
SHAVINGS VAULT
Thru Bolts
1½" Steam Jet
1½" Quick Opening Lever Valve Not exceeding 5'-0" above floor
1½"
CHIMNEY
Lightning Rod
Flue
Opening not to exceed 3'-0"x4'-0"
Vertical Sliding Fire Door
Automatic Closing
Provide a 2'-0" Sill above Boiler Room floor
10'-0" Minimum Distance
Furnace Door
BOILER ROOM
Dome
Main Steam Line
NOTE—All walls to be parapetted above roof at least 3'-0" unless roof is fireproof.

Fig. 10. Vault for Shavings

115. It is particularly important that the floor around door of shaving vault be kept cleaned up.

STEAM ENGINES.

116. Possibilities of fire include:

a—Steam pipes, either high pressure, exhaust, or connections to cylinder cocks, in contact with woodwork. The hazard is acute where high pressure superheated steam is used. See page 72.

b—Wood lagging on engine cylinders is objectionable only where, if ignited, fire could spread to some portion of the structure.

c—Placing of waste or rags on hot portions of engine.

d—Presence of oily wooden floors and oil accumulations in fly-wheel pits, where fanning action of wheel will intensify fire.

117. Because the engine room is generally the heart of the plant, it is particularly important that the greatest of fire prevention care be exercised at this point.

ELECTRICAL.

118. Electric power generating and utilization installations should in all details follow the National Electrical Codes. This applies to the type of apparatus, wiring, and control apparatus.

119. Especial care should be taken with installation of motors in rooms where inflammable vapors may be present.

120. Wooden platforms and bases of motors generally become oil-soaked, and motors should preferably be placed in heavy metal pans supported on metal.

121. The definite grounding of generators and motors is advisable both from a fire and an accident standpoint, as is the protection of exposed contacts on the frames of the machines. See also more detailed discussion of electrical hazards on page 31, and Fig. 3.

PRODUCER GAS.

122. Where these systems are used they should be installed in accordance with the rules and requirements of the National Board of Fire Underwriters. All pressure systems should be located in a special building provided for the purpose, also suction systems where feasible, except that small-sized gas producers, not exceeding 250 horsepower, may be allowed inside main buildings under certain restrictions. The installation of gas producers in cellars, basements, or any other places where artificial light will be necessary for their operation is considered hazardous and will not be allowed except by special permission of the underwriters having jurisdiction.

123. The suction producer is far safer from a life standpoint in that asphyxiation is not as likely to occur as with pressure producers, from which carbon monoxide gas may leak out and overcome persons in the vicinity. Less than 1% of carbon monoxide gas in the atmosphere may, in a comparatively short time, produce death.

GASOLENE ENGINES.

124. The construction and installation of gasolene engines is covered by one of the sets of rules issued by the National Board. Only permitted engines should be used. Supply tank should be located outside underground, where possible 30′ away from building, below the level of the lowest gasolene pipe in the building, and all piping should be arranged to drain back to the tank. Gasolene must be pumped to feed cup, and overflow from feed cup should return through separate pipe to storage tank.

125. Mufflers should be located at least 1 ft. away from woodwork or combustible material. Exhaust must extend outside without being carried through any floor, and it may not discharge into a flue because of danger of explosion of vapors in such a confined space. Electric ignition only should be used. Hot tubes, especially if heated by gasolene, introduce a positive hazard.

126. Engines are best placed on concrete floors, but where wooden flooring exists, steel plate extending 24 inches beyond engine base on all sides shall be used to protect wood. Adequate drip pans must be provided. Crank cases or shields should be used to prevent throwing oil.

127. Portable engines are covered by special rules. Gasolene storage is commonly in a tank in the base of the engine.

GAS ENGINES.

128. Gas engines are less hazardous than gasolene engines. The principal features to be safeguarded are the mufflers and exhaust pipes and the gas bags, which should preferably be in metal drums vented only to the outside. Hot tube ignition heated by gas is less hazardous than where gasolene is used. Electric ignition, however, is preferable.

KEROSENE ENGINES.

129. Kerosene engines are used to a considerable degree, especially for portable duty as on tractors and farm machinery. They generally use gasolene to start, and when hot the cheaper fuel is turned on. Speaking generally, the hazard is about the same as with a gasolene engine and the same safeguards are in order.

SELF-IGNITION ENGINES.

130. These, principally the "Diesel," inject oil of fairly high flash point and under very high pressure into the engine cylinders, and the heat of the compression ignites the oil vapor and air mixture. As the units are generally large, oil in considerable quantities is required, and special care in the installation of storage tanks is important. Only ten gallons of oil are allowed inside of the building for each engine as a supply to the high pressure oil pumps. Exhaust pipe hazards need safeguarding.

WATER POWER.

131. At first thought, a water wheel would seem to be free from fire hazard. Hot bearings, naked lights where oil and grease cover woodwork, and repair work introduce dangers, the remedies for which are obvious.

POWER TRANSMISSION.

BELTS.

132. The two principal hazards of belts are rubbing against woodwork and producing static electricity. See page 41.

133. Leather belts in both respects are more dangerous than fabric belts, and the larger the belt and the higher the speed, the greater is the danger as a rule.

134. Where belts pass through wooden walls or partitions, there should be allowed ample clearance to take care of side play, and if the motion of the belt is such that contact with the opening cannot be avoided, some form of metal roller or guard should limit the motion of the belt.

135. Wooden belt shifters are frequently used, and these should preferably be replaced with ones made entirely of metal, or the edges which come in contact with the belt should be protected by round or half-round-pieces of iron.

ROPE DRIVES.

136. The dangers of rubbing against woodwork are substantially the same as with belts. In addition, rope drives tend to throw grease and dirt, and periodic cleaning up is most desirable.

SHAFTING AND BEARINGS.

137. Overheated bearings are a frequent cause of fire, particularly in buildings where dust and lint accumulate as in grain elevators and cereal mills. Good practice requires that:

a—Shafting be well hung and well maintained, especially as regards alignment.

b—Hangers and bearings be kept clear of woodwork and arranged to avoid soaking woodwork with oil.

c—Self-oiling bearings be provided, which is desirable also from an accident standpoint.

d—Bearings and hangers be of a type that will readily permit of cleaning, and that they be kept clean through periodic attention.

PULLEYS.

138. Slipping belts on wooden pulleys frequently have caused fires, especially in flour mills and similar buildings. Tests have shown wooden pulleys under slip conditions to be far more dangerous than metal ones, and that canvas belts are safer than rubber or leather ones. The slipping of the pulley itself on the shaft is a definite hazard.

HEATING.

139. Certain heating hazards in connection with power generation are discussed beginning on page 51.

140. It is astonishing to observe under what apparently safe conditions it is possible for long continued low temperatures to cause fire. This matter is brought out under "Fire Dangers of Steam Pipes." Fig. 11 shows six specific cases of fires caused under conditions which the layman, at least, would consider safe. A particularly interesting example of this kind was the pair of roof fires in 1922 on the U. S. Treasury Building, in Washington, where heat from an oil burner, used to heat a kettle of roofing pitch, set fire to wooden roof boards through from 3″ to 4″ of sand. Each fire did considerable damage.

141. The persistence of fire and the unbelievable manner in which it may spread is illustrated in a report of a Department Store fire which appeared in the N. F. P. A. QUARTERLY of July, 1912. The gist was as follows:

> A rectangular boiler flue, covered with 1¾″ asbestos, ran parellel to a fire-resistive floor made up of 12″ of tile, covered with 6″ of cinder fill, in which rested sleepers for a wooden finish floor. The boiler flue covering came close to the ceiling, where two boards, used for centering when tile was erected, had been allowed to remain. The heat from the flue ignited the boards, fire crept upward between the joints in the tile, *ignited* the cinder fill, which contained considerable coke, and in turn set fire to the wooden floor above. The fire was stubborn, two calls being made on the fire department before it was extinguished. Property damage was slight.

142. Roughly speaking, any heating device so installed that it heats surrounding wood or other inflammable material to a temperature of 150° F. or slightly more, and for a considerable period of time, is likely to cause a fire. Every heat-producing device needs careful study as to possible fire hazard.

143. Solid masses of brick or concrete are almost worse than no protection at all. Safety lies either in entirely incombustible surroundings, or in so placing and supporting heat-producing devices that ample ventilation is secured.

CHIMNEYS AND FLUES.

144. Defective chimneys and flues rank fourth as a fire cause in the United States, and combined with the closely associated hazard of stoves, furnaces, boilers, and their pipes

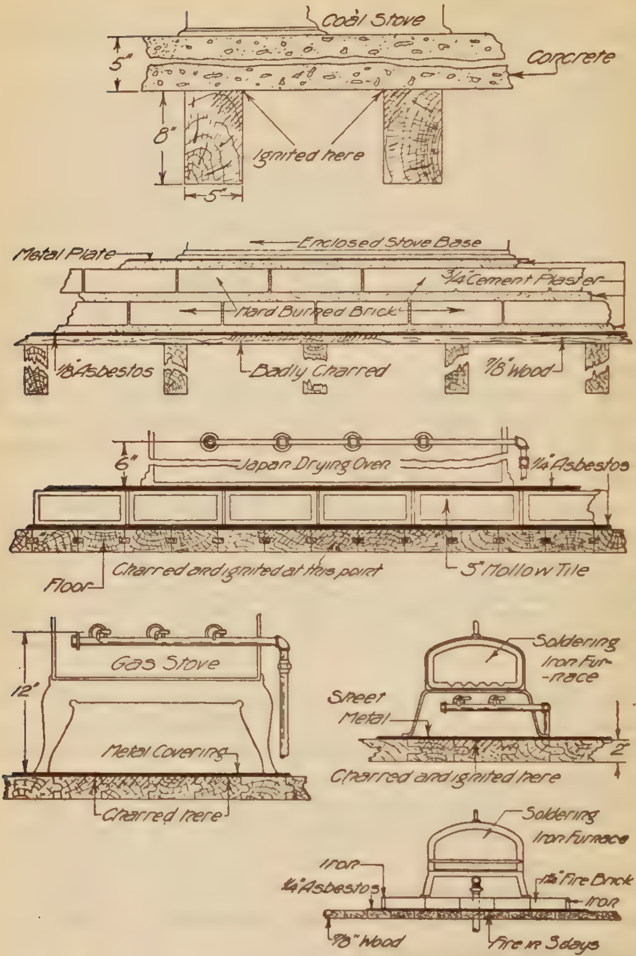


FIG. 11. FIRES DUE TO IMPROPERLY INSTALLED HEATING DEVICES.

which ranks third, produced 18.89% of all losses attributed to known primary causes. Admittedly the hazard is nationwide; the older the average chimney or flue becomes, the greater the danger. Literally criminal disregard of life has been displayed by builders in erecting thin-walled chimneys, without flue linings, with joists seldom over 4″ from the inside of the flue, and also actually let into the chimney wall proper. One of the most pretentious residences in the East was found with twelve chimneys so built, in all of which joists had been badly charred, but none yet quite far enough to get to the air, where the wood would have ignited.

145. The National Board Committee on Construction of Buildings has produced a model, practical chimney construction ordinance, which has been endorsed by a dozen national associations.

Essentials of this ordinance are:

a—Minimum thickness of a chimney 3¾″ (width of standard size brick) if brick or concrete or concrete block, 8″ if stone, and 12″ if rubble, in all cases to have fire clay flue lining.

b—For dwellings, flue linings may be omitted if walls are 8″ brick with inner course refractory brick.

c—Chimneys shall not rest upon or be carried by wooden floors, beams, or brackets, nor be hung from wooden rafters. Iron brackets or stirrups attached to wooden construction shall not be used to support chimneys. In frame buildings, chimneys shall always be built from the ground up or rest on basement walls.

d—Chimneys shall be built upon concrete or masonry foundations properly proportioned to carry the weight imposed without danger of settlement or cracking. The foundation for an exterior chimney shall start below the frost line.

e—A special cement-lime mortar is specified for chimney construction.

f—Minimum clearance of wood joists, beams, and rafters from face of chimney is 2″, and behind a fireplace 4″.

146. The danger from chimneys built on brackets comes largely from tendency to settle and open up cracks from which sparks can issue. Poorly built chimneys may be racked by the wind, and this result in cracks being opened, particularly in attics and at other points where they would not be readily noted. When a chimney is defective, it is frequently possible to build a new one on the outside of the structure, where it can be erected without interfering with the building itself.

147. For chimneys used for power purposes, see page 52.

148. The regular cleaning of chimneys, especially where wood or bituminous coal is burned, is essential to safety. The burning out of accumulated soot is dangerous, chiefly because sparks may ignite combustible roofs (see page 217) and, secondly, because the high heat of such a fire may carry through a weak chimney wall and ignite building. One argument for a thick chimney wall is that thin walls chill and cause more rapid precipitation of soot at the roof line.

STEAM.

149. The National Board classification of fire causes includes Steam and Hot Water Pipes. The risk is a comparatively moderate one, .31% of all losses being attributed to such pipes. There is a danger with moderate pressure steam pipes, and it increases with pressure, and especially where superheat is employed. Steam has temperatures of 212° F. at atmos. pressure; 267° at 25 lbs; 298° at 50 lbs; 338° at 100 lbs; 366° at 150 lbs; 387° at 200 lbs; 422° at 300 lbs. A case is on record of a 200 lb. 200 degree superheated pipe being wrapped in the same pipe covering with a fuel oil pipe. The latter leaked, oil saturated the pipe covering, steam ignited it, and an overhead fire resulted. The Collingwood School disaster was attributed to a steam pipe passing through a closet under the stairs. See Fig. 12. The Independence Bureau has written a treatise entitled "Fire Dangers of Steam Pipes" from which the following is extracted:

150. Steam pipes in contact with wood are admittedly the cause of occasional fires, though, manifestly, it is impossible to make a definite statement of the relative hazard from this source. It must always be borne in mind that in fires destruction is frequently so complete that the assignment of a cause is more or less a matter of conjecture. However, from our experience and that of others interested in this subject, we have gathered reliable data as to a number of cases in which steam pipes, under a variety of circumstances, have been without question a fire cause.

151. There is considerable diversity of opinion as to the circumstances under which such fires may be expected to occur, and the local conditions which contribute thereto. It is self-evident that the hazard is materially increased where the heat is in any way confined, or where contact is with materials more inflammable than wood. Particular care must be taken to guard against the presence of materials which are notably subject to spontaneous ignition, such as celluloid, coal dust, and oily waste.

152. A number of investigators have attempted to produce fires by bringing steam pipes into contact with various combustible materials, but as the duration of the experiments was comparatively short, few actual fires resulted. The conclusions generally drawn, however, were that any steam pipe, no matter how low the pressure, would in course of time produce charcoal, and that when this stage was reached positive danger existed. Charcoal is unquestionably subject to spontaneous ignition. This is due largely to its peculiar ability to absorb from the air many times its own volume of oxygen. This is held in the minute pores, which exist in all forms of wood charcoal. The combination of this oxygen with the carbon may take place with sufficient rapidity to raise the temperature to the ignition point. Furthermore, charcoal formed at a low temperature is known to have a low ignition point.

153. Where steam is kept on a system continually there is less danger than where on intermittently, according to some investigators. The reason advanced is that when allowed to cool the charcoal has a better opportunity to absorb oxygen than if kept hot at all times. Another factor is moisture. Experiments have shown that charcoal, once wet and dried out afterwards, is more dangerous than that which has remained dry, ignition points being well below the boiling point of water in a number of laboratory tests.

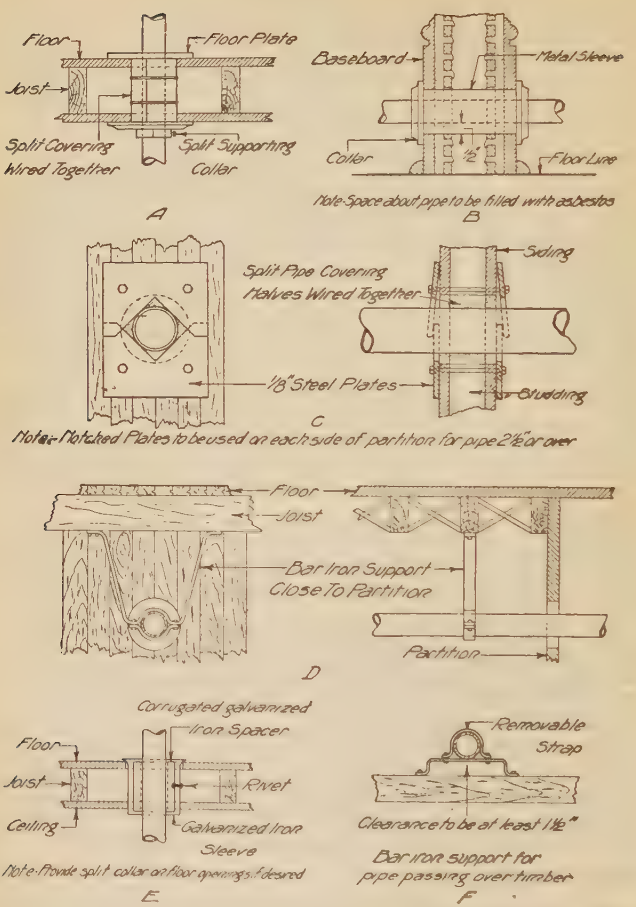
154. In our opinion reasonable precautions should be taken to keep steam pipes from contact with woodwork or other combustible material. This is of more importance with high pressure than with exhaust steam pipes, and more so in confined spaces than out in the open where there is free air circulation and freedom from accumulation of combustible dust and dirt.

155. Combustible material should not be allowed to rest against or surround the pipes. The overhead method of piping is generally preferred. Steam heating becomes a special hazard when used for kilns, dry boxes, caul boxes, etc. In such cases the heat is usually high and long-continued, and sawdust, chips, and shavings are liable to collect around the pipes and cause fire.

156. There are two general methods of keeping steam pipes free from contact with combustible material, first being through the use of an insulator, such as pipe covering, and the second by supporting them rigidly at a safe distance. Wherever pipes pass through concealed spaces, covering should preferably be carried for entire length, to avoid future contact with substances which may get into these spaces. Fig. 12 illustrates desirable principles, which, while shown applied to certain specific problems, can be adjusted to fit practically all conditions.

HOT WATER.

157. Hot water heating systems, in so far as pipes are concerned, are considered to be practically non-hazardous. The pipe temperature is ordinarily well below the boiling point of water, and hence incapable of igniting wood. A hot water pipe can, however, materially stimulate spontaneous combustion.



Note-Space about pipe to be filled with asbestos

Note:-Notched Plates to be used on each side of partition for pipe 2½" or over

Note-Provide split collar on floor openings if desired

Bar iron support for pipe passing over timber

FIG. 12. PROTECTION FOR STEAM PIPES.
(Courtesy of Independence Bureau.)

HOT AIR.

158. The chief hazard from this method of heating comes from the blower or intake, for it is evident that a fire at this point may be blown through the building. A case is on record where a plant consisting of nine structures was destroyed by such distribution of fire. The blower should be kept clean, and, to facilitate internal inspection and cleaning, there should be a door giving access to the blower case. Blower should be kept well oiled and properly adjusted, and the bearings should be on outside to prevent oil from getting into case.

159. Intakes should be located so as to be safe from sparks, and air should be taken from outside through a screened opening. It is exceedingly undesirable to take air from inside of building, if there is any possibility of fire starting at that point. Systems arranged to circulate air in a building, that is, to take air from the various floors through suction pipe and then deliver it back again, are especially to be feared. The National Board rules contain diagrams of fusible link controlled dampers in ducts, and these are occasionally advisable. Automatic stopping devices for fans or blowers are sometimes used. See the National Board rules of Heating and Ventilating Systems, and Stock and Refuse Conveying.

160. Hot air heating for dwelling houses, contrary to the common impression, involves considerable fire hazard. Essential safeguarding measures include:

a—Ceilings closer than 3 feet to heating boilers, furnaces and stoves, and over fuel storage other than anthracite coal or coke, shall be plastered on metal lath to extend not less than 12 inches beyond the outline thereof.

b—Horizontal hot air furnace pipes must be not nearer than 6″ from wooden floor beams or wood lath and plaster ceilings unless protected with at least ½″ of asbestos or metal lath and plaster, in which cases the clearance may be reduced to 3″.

c—Hot air pipes passing through combustible partitions or floors must be double metal pipes, with at least 1" air space between them.

d—Hot air pipes in partitions shall have not less than ⅜" air space between double walled pipes or be covered with at least ½" of asbestos, and neither the outer pipe nor the covering shall be within 1" of wooden studding. Metal lath and plaster shall be used on channels where hot air pipes are run.

e—At least one register should be without valves or louvers to prevent overheating of furnace.

RANGES.

161. Ranges of the hotel type resting directly on the floor are more hazardous than stoves on legs. See Fig. 11 for examples of what may happen with ranges where conditions would ordinarily be deemed safe. The chief features bearing on fire safety are:

a—Ranges to rest preferably on incombustible floor construction, but if not possible, to be placed on steel I-beams about 6" high to afford definite ventilation, and these beams in turn to rest upon large sheets of zinc extending well in front of range and to both sides. There must be ventilation; boxing up the space will not answer. See par. 162c.

b—Ranges to be placed against brick or other incombustible wall, and if wall is wood or wood lath to be set away at least 24". See also par. 162a.

c—Stove pipes to be treated as set forth in par. 162b.

d—Hoods by means of which vapors are taken off to be kept free from grease and dust, and the same thing to be true of the separate ventilating flue to which such hood should connect. This flue should be the equal of a chimney. Many dangerous fires have resulted from sheet metal vent flues becoming red hot and setting fire to the building; often at some distance from the kitchen.

COAL AND WOOD STOVES.

162. The hazards of coal and wood stoves, aside from combustible material being left too near them, are milder than ranges, because they generally are smaller, are not provided with hoods in which grease can accumulate, and are supported on legs away from floor. The essential safety features include:

a—Any combustible partitions within 24″ of a range or stove shall be protected against heat for a space equal to the length or width of the range plus 6 inches on either open side or end and from the floor to the ceiling, where stove pipes occur, and not less than 4 feet high elsewhere, by using special protective construction not less than the following:

Sheets of cellular asbestos, not less than ½-inch thick, to be nailed to the studs, completely covering the areas just mentioned. Over this place metal lath arranged to have an air space of 1 inch from face of asbestos to face of lath either by using plain lath on non-combustible furring blocks, rings or strips, or by using metal lath of self-furring types.

The metal lath to be then plastered with three coats of the same plaster as the remainder of the room, or one coat covered with tilework or slate.

The corners of the shield or protection thus formed shall project one inch and be chamfered or rounded back to the wall and the wood skirting shall be butted against same and omitted at back of or at ends of ranges.

b—Stove pipes shall be kept in good repair, with tight joints, well supported, and regularly cleaned. The best installation rules call for the following:

Smokepipes shall enter the chimney horizontally, connecting to the flue through the chimney wall with round tile or metal thimbles set in the chimney with cement mortar.

Connecting thimbles shall fit the smokepipe snugly and shall be provided with a metal collar, secured to the chimney.

Smokepipes shall be located not closer than 24 inches to any woodwork, nor closer than 6 inches to any metal lath and plaster.

Smokepipes shall not pass through combustible floor, roof, partition, or wall construction unless a section of the construction is removed and the smokepipe is insulated from the construction by a galvanized iron, double walled, ventilated thimble having a diameter of not less than 12 inches larger than the pipe, or by not less than four inches of incombustible construction.

Smokepipes shall not be permitted in closets nor in concealed air spaces and shall not be permitted to connect with the chimney in the attic or garret.

All smokepipes shall be firmly connected at the inlet and outlet and shall be securely anchored in position throughout their length.

c—Floor protection to consist of zinc plate extending at least 18″ in front of stove, 12″ beyond each side, and back to wall.

FIREPLACES.

163. Improperly built fireplaces are a decided fire menace. Thin walls, combustible material against their backs, combustible mantels, combustible finish on face of chimney, and unsafe hearths are common causes of fire. Fig. 13 shows the standard fireplace construction as recommended by the National Board Building Code.

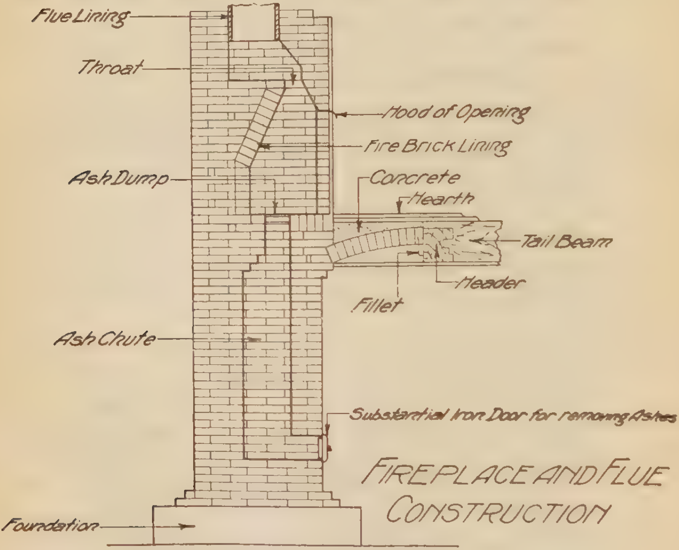


FIG. 13. STANDARD FIREPLACE AND CHIMNEY.

164. Screen protection, partly to keep sparks from jumping out onto the floor, and partly to prevent children and adults from having their clothing ignited, are essential for every fireplace that is used, even if only occasionally.

ASHES.

165. There is a case on record of a ten-year-old ash dump catching fire spontaneously. Ashes, even if known to be cold or wet, should never be stored in or in proximity to combustible material. Storage in cans or on cement floors is proper. Mixing inflammable refuse with ashes causes many fires.

GAS STOVES.

166. See page 42 for general hazards of gas and gas consuming devices. See also Fig. 11. If stoves are of the hot plate type, they should preferably be placed on all metal supports, or if they must be placed on wood, at least ¼″ asbestos protection covered with zinc should be provided. Pipe connections are essential, as is keeping combustible material from their vicinity. Large gas ranges may require the same treatment as coal ranges, and should be connected to a regular flue. This is vitally important for the instantaneous type of water heater.

PRESSING IRONS AND HEATERS.

167. The electric pressing iron hazard is discussed on page 40. Gas heaters used for irons should be treated as gas stoves, for which see preceding section.

168. Pressing irons with gas burners inside may become exceedingly hot and they require supporting stands with at least 3″ of clear air space separation between the base of the iron and any combustible material upon which the stand may rest. The best design calls for a metal bracket or shelf set away from the wooden table or board. Good tubing, well mantained, with shut-off cock at pipe end of tubing is essential.

GASOLENE STOVES.

169. These are unquestionably hazardous, and should never be used if avoidable. Where used, they should be of the type permitted by the Underwriters' Laboratories, with removable oil font that can be taken outside for filling.

KEROSENE STOVES.

170. A far safer device than a gasolene stove is the blue flame kerosene oil stove. Where coal, wood, or gas is not available, kerosene should be the fuel.

ELECTRIC HEATERS.

171. For detailed discussion of electrical hazards along heating and other lines see pages 34 to 42.

ALCOHOL STOVES.

172. The chief danger of these stoves lies in spills of burning alcohol and in combustible material coming in contact with them. Stoves, if used, should rest upon a liberal-sized metal tray. The newer design of stoves using alcohol in solid form reduces the hazard somewhat.

FORGES AND FURNACES.

173. In industrial plants there is found a large variety of forges, furnaces, kettles, kilns, ovens, retorts, and other devices heated by gases, liquids, solid fuels, electricity, and steam, both of the stationary and portable types. The fundamentally important principles include:

a—Installation with due regard to possibilties of igniting woodwork. See page 69.
b—Where gas is burned, use of pipe instead of tubing, and provision of adequate and safely located shut-off valves. See page 44.
c—Proper disposal of ashes.
d—Indicating lights to show when electric current is on devices.
e—On page 62 will be found data regarding portable types of oil burning forges and furnaces.

174. An important item in connection with gas burning devices is to have valve arrangement such that the higher pressure air supply cannot be forced back into the gas system with ultimate possibilities of explosion, especially in the meter. In other words, there should be one valve on gas supply and one on air supply, but no valves on the joint line leading to the device.

175. Gas heated furnaces, commonly found on wooden benches, can advantageously have section of wooden bench cut away, steel plate placed over opening, and gas furnace fastened centrally on such plate. See Fig. 11.

JAPANNING AND ENAMELING OVENS.

176. Japanning and enameling ovens, which are used in connection with coatings containing inflammable solvents, are found to a considerable degree in metal working industries, ranging from very small work to automobile parts. The record of such ovens has not been good, serious life as well as property loss being recorded. An N. F. P. A. analysis of 174 fires due to japan and lacquer gave as principal known causes for japan: overheated ovens, 16.8%; explosions at ovens, 15.3%; smoking, matches, and open flames in presence of japan, 13.0%; heat from oven igniting nearby material, 9.2%. For lacquer the principal known causes were: matches or open flames in presence of lacquer, 32.6%; accidental sparks, 16.3%; lacquer spilled on hot pipes, 9.3%; overheated ovens, 7.0%; spontaneous combustion of lacquer refuse, 9.3%. Furthermore, 11 lives were lost in a 3-story, brick-joisted, unsprinklered button factory in Newark, in 1918, when a motor spark ignited nearby lacquer. The 1922 Proceedings of the N. F. P. A. contain a treatise on the dangers and the necessary safeguards, from which a few high points are here presented.

a—The source of heat may be steam coils, hot air from a remote source, hot oil circulating in pipes, gas, or electricity. The essential safeguards are:

b—Steam: metal supports and no traps to produce water hammer.

c—Hot air: remotely located fans using outside air without re-circulation.

d—Hot oil: detached oil heating furnace and pipes, no expansion tanks or reservoir near oven; 600° flash point oil; automatic stop valve in oil supply to burners.

e—Gas: No connection between combustion tubes and oven proper; burners so located that fumes not likely to reach them from dipping room or front of oven.

f—Electric: Heating elements out of line of dripping and with screen protection; automatic temperature regulation; remote control and instruments.

g—Ventilation of Oven: Adequate to prevent accumulation of explosive mixture.

h—Location of oven away from high values or many people, preferably in detached 1-story building, above grade, on account of heavy fumes being produced; not erected on wooden floors.

i—Under some conditions ovens require explosion covers.

177. A recent development has been the succesful use of a water japan, representing a very mild hazard compared with one using an inflammable solvent.

SALAMANDERS.

178. On construction jobs in particular, and also in unheated shops, are found in winter numerous salamanders, often decrepit metal drums with a few holes punched in them. Where there is combustible material around, as is likely to be the case on a construction job, there may be acute fire hazards, and as there are no chimney connections, and poor combustion often occurs, there is danger of carbon monoxide poisoning. Reasonable safeguards where salamanders must be used are:

a—Reduce use to a minimum; provide safer forms of heat if possible.

b—Use a safe, rugged design of salamander.

c—Have locations where used subject to approval of some one in authority.

d—Keep them out of traveled passageways or points where they may be upset by work going on.

e—Burn coal or coke only; wood produces a serious spark hazard.

f—Make sure that extinguishing apparatus of non-freezing type is available.

g—Do not use them where there is no watch service after the end of the working day.

SAND DRYERS.

179. In many properties, especially those of steam and electric railways, sand has to be dried in large quantities. The enclosure in which dried sand is confined should be entirely non-combustible. Sand holds heat for a long period, and fires have been caused from steam coils even when the wooden enclosure was at a reasonable distance from the coils themselves. Where stoves are used, the smoke pipe or flue hazard also exists.

TORCHES.

180. Gasolene torches are commonly used for repair purposes, and should be filled and kept, when not in use, outside of important buildings. Torches leak not infrequently, and when left inside, particularly in lockers, constitute a fire hazard of no inconsiderable proportion. The risk of burning off paint is often very acute. The use of a paint remover, although dangerous, is usually less so than the use of a torch.

181. Kerosene torches work upon the same principle as gasolene ones, are in successful use, and should be employed where possible.

182. On a small scale and for small work, alcohol torches are used, and are unquestionably less hazardous than gasolene.

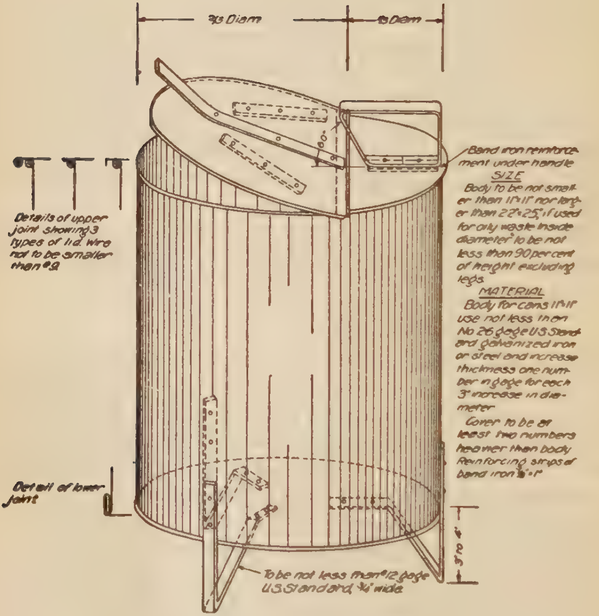
HOUSEKEEPING.

183. Good housekeeping, by which is meant proper attention to matters of cleanliness and order, is the foundation of effective fire and accident prevention. Not only is the direct effect decided, but the important indirect value of the influence of a clean plant on the working force is also great. It produces respect for orders, greater personal care, and better upkeep of equipment.

184. There is a tendency to assume that so long as combustible refuse is not allowed to lie about a plant, housekeeping is satisfactory from a fire prevention standpoint. In so far as eliminating causes of fire is concerned, this is practically true, but to make for generally good conditions, and to put forward accident prevention, the nearest possible approach to immaculate housekeeping is advisable, and the rule "A place for everything and everything in its place" should be enforced.

REGULAR CLEANING.

185. The maximum result for the minimum effort comes from daily or even more frequent sweeping up and collection



Details of upper joint showing 3 types of lid. Wire not to be smaller than #9

Band iron reinforcement under handle

SIZE

Body to be not smaller than 17"×17" nor larger than 22"×25", if used for oily waste inside diameter to be not less than 90 per cent of height excluding legs.

MATERIAL

Body for cans 17"×17" use not less than No 26 gage U.S. Standard galvanized iron or steel and increase thickness one number in gage for each 3" increase in diameter

Cover to be at least two numbers heavier than body

Reinforcing strips of band iron 1/8"×1"

Detail of lower joint

To be not less than #12 gage U.S. Standard, 3/4" wide

FIG. 14. NATIONAL STANDARD WASTE CAN.

of refuse. Employees should be required to minimize the cleaning required by depositing in receptacles provided for that purpose, and as produced, all dirty waste, refuse, packing materials, etc. Condition of floors, methods of piling or racking materials, illumination, and cleaning equipment, as well as capable men, bear on the desired result.

186. Refuse barrels and waste cans, as described later, should be emptied preferably each day at the end of the day. Leaving material till morning may result in a night fire. Special trucks for collecting receptacles or their contents make for economy in a large plant. The use of baling presses for large accumulations of waste paper is good practice, particularly where paper stock and press are located in a cut-off room under sprinkler protection.

187. Inspection, after the cleaning is supposed to be completed, is resorted to in many plants. Foremen, in rotation, spending an hour or two in this work are used by a plant whose housekeeping is practically perfect.

OILY MATERIALS.

188. Oily waste, oily clothing, and finishing rags, particularly if containing oils subject to spontaneous ignition, such as linseed, cotton seed, and other vegetable oils, are highly dangerous. Animal oils are dangerous; mineral ones much less so. All oily or dirty waste must be treated properly if fire hazard is to be avoided. See page 103 for spontaneous combustion.

189. Oily sawdust, lint, etc., are also subject to spontaneous combustion. For all such materials in ordinary quantities, the National Standard waste can, shown in Fig. 14, is best. Approved cans bearing the label of the Underwriters' Laboratories are particularly substantial. For large amounts, heavy metal barrels with loosely fitting covers (so they will not be hard to get on and off) are recommended.

CLEAN WASTE.

190. This is generally considered to be mildly hazardous, chiefly because it is readily inflammable when not baled, and there is always the likelihood that dirty waste may become mixed with it. Occasionally fires are reported in clean waste where there seems to be no question but that spontaneous combustion was responsible for the outbreak. Moisture is usually a factor in such cases. Reclaimed waste is unquestionably somewhat more dangerous than new waste. It is now common practice to handle clean waste in the same manner as dirty waste, although it is quite obvious that the fire hazard is materially smaller.

191. Principal supplies of clean waste are best kept in bins, either made entirely of metal or of wood lined with metal, and provided with covers which are kept normally closed. Several bins may be provided where the supplies are large, or where different kinds of waste are kept. The covers on such bins should preferably be counter-weighted so that they may be readily raised and lowered, and counter-weight ropes can have fusible links to insure automatic closing of covers in event of fire. See Fig. 15. Local supplies of clean waste are usually kept in small waste cans, properly marked.

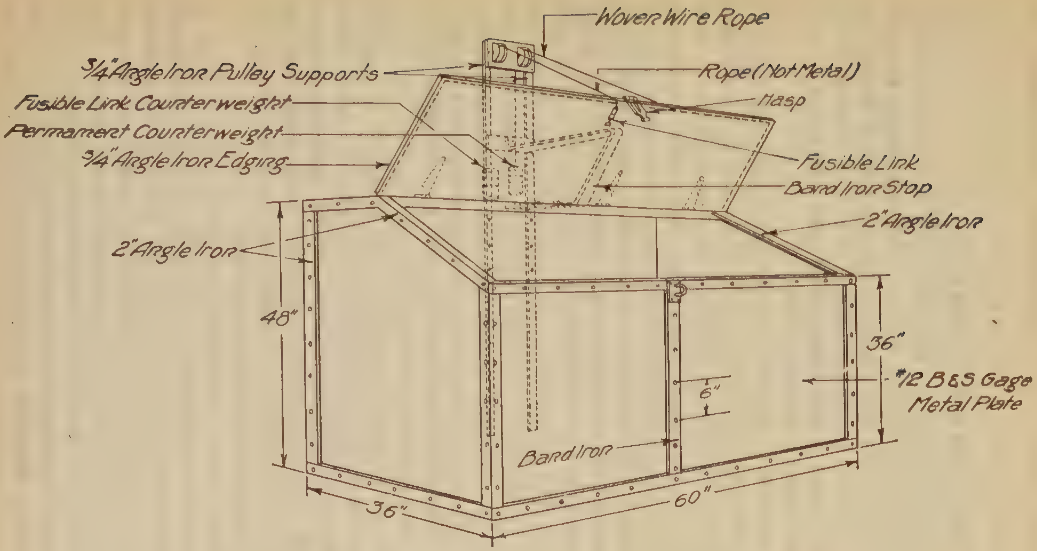
192. By providing local supply points for clean waste, it will be possible to get away from the customary practice of keeping waste in clothes lockers, drawers, benches, and similar points. There is the danger that if clean waste is allowed in such places, some which is more or less dirty will also be placed there, with possible resulting fire.

DRIP PANS.

193. Metal drip pans are essential at many locations, notably under motors, machines using cutting oils, bearings, and in connection with borings and turnings that may contain some oil. Wooden boxes, especially filled with sawdust, are particularly objectionable. Sand is the best absorbing material where one must be used. Regular emptying, preferably at the end of the day, is recommended.

PACKING MATERIAL.

194. Excelsior, straw, sawdust, burlap, etc., are all dangerous, and should be treated similarly to clean waste, except that where large quantities are used special vaults or store rooms frequently are needed. Automatic sprinklers are de-



Note: Provide Hasp with stop so that it will not engage top edge of bin while lid is closing. Band Iron Stop should not exceed 60° from the horizontal.

FIG. 15. BIN FOR STORAGE OF WASTE AND PACKING MATERIAL.

sirable in such rooms, even if the balance of the plant is not protected.

LOCKERS AND CUPBOARDS.

195. The danger from lockers lies chiefly in lack of cleanliness, particularly as regards oily or painty clothes, and oily waste or rags. Pipes and cigars, not extinguished before being placed in lockers, and matches are also objectionable. All of these dangers are minimized with metal lockers or rigorous inspection of wooden ones.

196. Metal lockers should be of such size that clothing may all be hung up, and have solid backs and solid dividing partitions rather than those made of expanded metal or wire screen, as any fire can more readily be confined to one locker with the solid type of construction. The "two high" locker is unsatisfactory. It will not hold clothes without mussing them and hence they are often kept outside. Punched plate, expanded metal, or screen doors are used in connection with such lockers. The punched plate doors have the advantage of keeping out dust and dirt, and are therefore preferred by employes. Improvements can be effected in wooden locker installations by providing them with screen or expanded metal doors, in order that interiors can, to a certain extent at least, be seen without opening them.

197. Where automatic sprinklers are installed, expanded metal or screen tops are necessary to enable water from sprinklers to reach contents. Paper can be pasted on top to keep dust out. Sloping tops are advisable both from the fire and the accident prevention standpoints, as material cannot be placed on top of a locker so designed.

198. Wooden supply cupboards constitute a fire hazard in such places as machine and paint shops, where woodwork becomes oil or paint soaked, and where there is a possibility that clothes or oily waste will be left in same. At all such points, regular inspection is necessary to make certain that proper conditions of cleanliness are being maintained. The ideal cupboards for tools and similar materials are ones made entirely of steel. Wooden ones lined with metal are a step in the right direction.

BLOWER SYSTEMS.

199. National Board Rules cover Blower Systems for Heating and Ventilating and Stock and Refuse Conveying. Certain essential safeguards for heating and ventilating systems are covered under Hot Air, on page 75. Stock and refuse conveying is generally far more hazardous. The rules for safeguards are specific. General ones are:

a—Blowers through which inflammable materials pass shall have blades of composition, copper or brass. Ample clearance shall be provided for all blades.

b—Ducts for conveying stock and refuse shall be made of suitable non-combustible materials, preferably galvanized iron. All joints shall be riveted or lock-jointed and soldered.

c—Suitable tight-fitting sliding clean-out doors shall be provided on all conveyor ducts at sufficient intervals to facilitate cleaning of ducts or removing obstructions.

d—Suction ducts shall be provided at all machines producing dust or combustible refuse, and shall be connected to exhaust fans.

e—"Sweep-up" pipes should be so protected as not to admit material which would be large enough to damage blower.

f—Trunk line should be run on the outside wall of the building with ducts from each machine and each floor, passing out directly through the wall and discharging into the trunk line. If inside of building, the trunk duct shall be overhead rather than under the benches.

g—The air vents from the system shall discharge outside of building.

h—The cyclones or separators shall be outside the building, and so located as not to constitute a hazard to adjacent structures. Their construction and supports shall be of incombustible material. If the cyclone of necessity is placed within 10 feet of wooden walls, inflammable structures, or openings into buildings, it shall be provided with a metal pipe extending to a point above the main roof, or other safe location.

i—The refuse from the cyclones and separators is to discharge by gravity into a vault. See page 64.

j—If the discharge from the cyclone or separator conveys the refuse directly to the fire boxes of boilers, the feed spout shall have an open end discharging into a suitable receiver near the furnace, so that when the furnace gets choked the refuse will fall out on the boiler room floor giving the fireman a warning, also it would prevent "back fire" when the fan blowing the refuse is stopped.

k—The dust from sand-papering machines, granulators and pulverizers, buffing or polishing wheels, emery wheels, and from other machines producing a very fine dust, shall have a suction system independent of the cyclone, which connects with the refuse vault.

l—The dust should be settled by spraying in an enclosed chamber of incombustible material, thus eliminating the hazard of the dust room. Dust from the machines may also be discharged directly into running water if suitable provision is made for its collection and removal.

m—For mills, such as malt, cereals, sugar, celluloid, etc., it is recommended that an explosion flap be provided in a metal pipe leading outside of the building so that in case of an explosion in the mill the flap may open and the explosion spend itself outside the building.

OILS AND PAINTS.

200. As here discussed, the subject of oils deals with lubricating and paint oils. See page 55 for fuel oil, and following pages for more volatile liquids. Oils and paints constitute a considerable fire hazard, chiefly because spontaneous combustion in connection with waste, finishing rags, burlap, sawdust, etc., is possible, and because, once on fire, stocks of this kind burn with fierceness and are hard to extinguish. The following general sugggestions merit careful consideration.

LARGE STORAGE.

201. If a plant uses any oil in tank car lots, underground buried tanks (pits are objectionable because vapors can accumulate) or above ground tanks protected by retaining walls or enclosed in earthern embankments are advisable. Supply of oil for regular use can properly be drawn from underground tanks by pumps located in the oil house, and occasionally, by special arrangement with the Underwriters, such pumps may be located in a manufacturing building or in a garage. Sometimes a small adjoining but cut-off room is used.

OIL HOUSE.

202. For the usual plant supplies of oils or paints, a separate, preferably detached, oil house is generally desirable.

203. If the quantities of oil purchased are small and a building is unusually well built, as, for example, a fire-resistive power station, an oil house is hardly necessary. It does not follow that an oil house need be of expensive fire-resistive construction, although this form of construction is best, particularly if it has to be comparatively close to other buildings. If considerable open space exists, an oil house can be constructed economically of corrugated iron on steel or timber frame, and perhaps with a concrete floor to encourage cleanliness.

204. Fig 16 shows a plan and an elevation of a model oil house of strictly fire-resistive construction. The following specifications accompany the drawing:

CONSTRUCTION.

Walls—Brick, stone, or concrete.
Roof—Concrete without exposed steel.
Floor—Concrete, drained to one point.
Sill—Raised about 6″ from the floor.
Door—Standard metal or tin clad, automatic sliding or swinging.
Windows—Metal frame and wired glass.

OIL HANDLING.

Oils of which large quantities are used to be outside, in underground tanks with pumps inside building.

Vents from tanks to be carried above roof, down-turned at upper end and screened.

Other oils in barrels or large cans to rest on concrete well above floor. Small cans on metal shelves.

Drain to run to sewer or other convenient point, and to have deep trap.

Drip pan to be provided as shown.

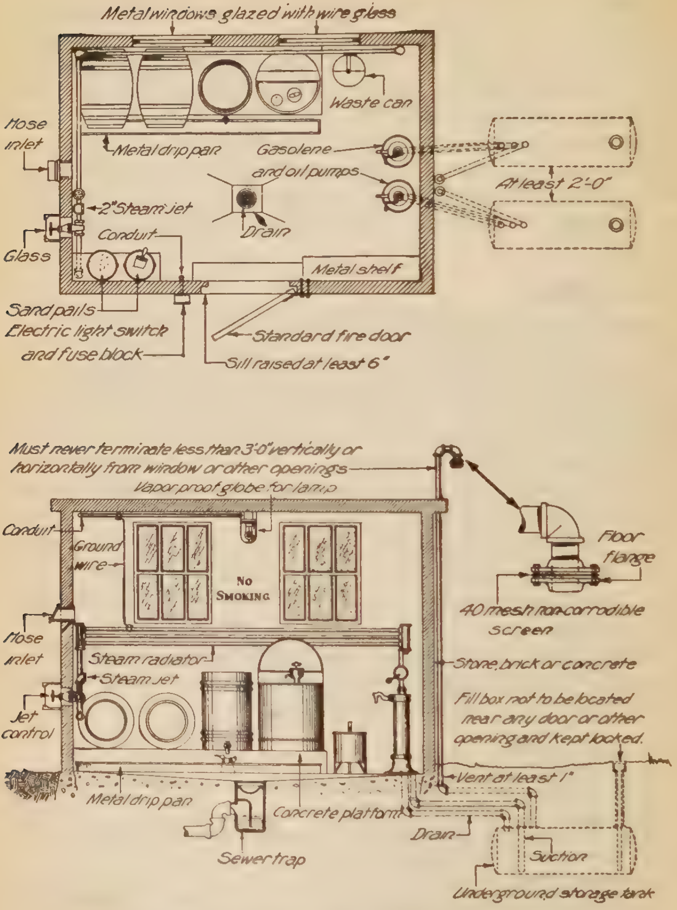


Fig. 16. Suggestions for Construction and Equipment of an Oil House. (Courtesy of Independence Bureau.)

EXTINGUISHING APPARATUS.

Hose Nozzle Inlet—Three-inch pipe through wall with swinging cap enclosure on outside.

Steam Jet—About 2″ high pressure connection, with controlling valve inside building and hand wheel through wall to outside.

Chemical Extinguishers—Foam or one or two carbon tetrachloride approved extinguishers, and preferably also a soda-acid extinguisher.

Sand Pails—For small oil house, three sand pails with large scoop on shelf at door. For large oil house, bin of sand with scoop shovel. See page 454.

MISCELLANEOUS.

Heating—By steam coil above barrels, and at least 6″ from wall. Supply pipe to be covered from floor.

Lighting—Wiring to be in conduit with keyless sockets and vapor-proof globes. Controlling switch and fuses to be outside.

"No Smoking" signs to be provided. See Fig. 20.

Waste Can—to be National Standard type with gravity closing cover.

205. Many of the principles set forth can be successfully adopted even in a building which is not a model of its kind. The underground storage of the principal oils handled has not only a great advantage from a fire standpoint, but it permits of the construction of a building small in comparison to the quantity of oils handled. The use of permitted storage tanks and pumps is urged.

206. An oil house should have as little combustible material in its construction as possible, as wood readily becomes oil-soaked. For example, barrels should not be placed upon wooden racks, but either upon the cement floor directly, upon concrete blocks, or on iron pipe or rail frames. Out-of-the-way corners in which waste and similar materials can accumulate should be avoided. For this reason, a concrete base is to be preferred.

207. If an oil house is located at a point where sparks might get into it, or where there is danger of passersby throwing cigar or cigarette butts or matches into the building, the walls should be made as nearly windowless as possible on the exposed side, and the windows which are necessary should be provided with ⅛″ to ¼″ galvanized iron screens.

INSIDE OIL ROOM.

208. Occasionally, where an outside oil house is not feasible, an oil room is built inside of a building, and the same construction features as above set forth are desirable. Such a step must only be taken with the approval of the Underwriters having jurisdiction. The objection to such a room may be great in a poorly built structure, and small in a first-class fire-resistive one.

PUMP TANKS.

209. In addition to the use of permitted forms of pumps (measuring if desired) for drawing oil from underground supply tanks, individual heavy metal pump tanks generally about 60 gallons capacity are placed in oil houses, oil rooms, engine rooms, or even in manufacturing or mercantile areas for providing and handling safely a moderate amount of fluid. Where liquids of high flash point are handled, such tanks introduce very little hazard, and the use of pump tanks should be encouraged.

LOCAL SUPPLIES.

210. Almost every plant requires local supplies of oils and paints to facilitate operation. Advisable rules are:

a—Have supplies as small as possible—a one day's supply being good practice. Return unused material to oil house at end of working day.

b—Use only metal containers.

c—Keep these in a steel pan supported on steel frame or brackets. Wood soon becomes oil-soaked. See Fig. 17.

d—The minimum protection advisable for wooden benches and shelves is zinc covering.

GASOLENE AND OTHER INFLAMMABLE LIQUIDS.

211. Petroleum and its products is the ninth most serious cause. See page 30. Undoubtedly a large percentage of these losses have been due to the more volatile and consequently more hazardous petroleum products. The preceding section of this book deals with oils and paints, and on page 55 will be found data regarding fuel oils.

212. There are extant today, bearing on this problem, the following sets of regulations:

a—N. F. P. A., 1923, Containers for Storing and Handling Inflammable Liquids.

b—N. F. P. A., Oil Burning Equipments and the Storage of Oil Fuels.

c—N. B. F. U., 1921, Suggested Ordinance Covering Use, Handling, Storage, and Sale of Inflammable Liquids.

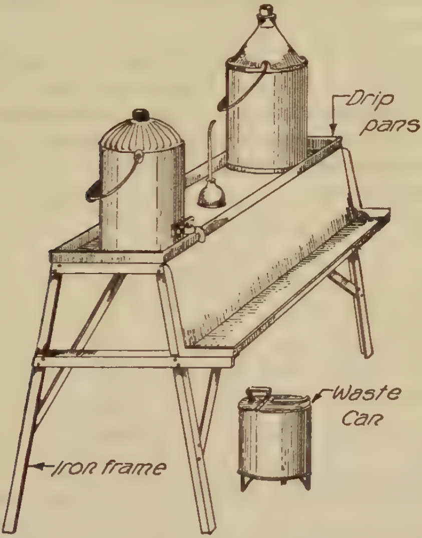


Fig. 17. Metal Oil Can Rack with Drip Pans

213. There is some discrepancy as between these regulations, which, no doubt, will be eliminated in due course. For conditions governing storage tanks and oil-burning safeguards, see pages 55 to 62.

214. The 1923 regulations divide all inflammable liquids into three classes according to flash point as follows:

Class 1—Liquids with flash points below 25° F. Closed Cup Tester.

Class 2—Liquids with flash points above that of class 1 and below 70° F. Closed Cup Tester.

Class 3—Liquids with flash points above that of Class 2 and below 200° F. Closed Cup Tester.

215. Flash points to be determined with the Abel-Pensky or the Pensky-Martens closed cup tester. For commercial use where the flash point is not within 9 degs. F. (5 degs. C.) the Tagliabue open cup tester may be used, provided that the flash point as given by the Abel-Pensky or Pensky-Martens testers shall be authoritative in all cases.

216. The N. F. P. A. made a study of 1,000 fires due directly to hazards of benzine, benzol, gasolene, naphtha, fuel oil, alcohol, kerosene, ether, or other inflammable liquids of the same general type, covering an experience of 17 years. The records show the number of fires in these materials to have been as follows:

Name.	Number of Fires.	Percentage of Fires.
Benzine	771	77.1
Alcohol	65	6.5
Fuel Oil	64	6.4
Kerosene	46	4.6
Unknown	54	5.4
Total	1,000	100

217. The term benzine includes also benzol, gasolene, and naphtha.

218. Particular attention is called to the efficiency of sprinklers in controlling fires of this kind. 618 fires took place in sprinklered plants, and 588 in sprinklered sections. The average number of heads opened was 9.15 with wet, and 15.77 with dry systems.

219. See tables Nos. 40 and 41, page 736, for Explosion Temperatures and Explosion Range of Gases.

220. The inherent hazards because of inflammability and relatively great weight of vapors, which causes them to disperse slowly and to seek low places, make the storage and handling of the usual commercial inflammable liquids a matter of great moment from a fire prevention standpoint.

221. The classification of causes is given as follows:

Causes of Fires.	No of Fires.	Per Cent of Total Known Causes.
Open Flames	240	26.7
Matches	135	15.0
Static or Frictional Electricity	100	11.1
Electric Sparks	62	6.9
Miscellaneous Explosions	60	6.7
Defects in Devices	58	6.5
Careless Use of Devices	54	6.0
Miscellaneous Sparks	44	4.9
Explosions of Lamps, Lanterns, and Stoves	42	4.7
Smoking	30	3.3
Automobile Back-firing and Cleaning	29	3.2
Miscellaneous	45	5.0
Total	899	100.0
Cause Indeterminate, not Reported, or Unknown	101	
Total	1,000	

STORAGE AND HANDLING.

222. The **Hydraulic system**, which discharges liquids not miscible with water by the admission of water at the bottom of the storage tank, is the safest known because no air and vapor mixture exists in such a system.

223. Air pressure used for discharging any form of inflammable liquid from a storage tank is inherently hazardous because:

a—Broken pipe or fitting in the building will discharge large quantity into a fire, or may be the cause of a fire. With a pump system, the limit of flow is the capacity of the pump, which is generally small.

b—The storage tank or a fitting may fail, due to over-pressure or defective construction.

c—When tank is refilled, it is necessary to release a large amount of air charged with vapor.

224. Where pressure systems are used, they should be especially well installed, operated at low pressure, provided with relief valve on tank, and automatic shut-off valves in discharge lines. See Fig. 9, page 60.

225. Portable tanks are commonly used for filling purposes in garages and for replenishing local supplies in some industrial plants. A number of types are passed by the Laboratories. Capacity is usually not over 60 gallons.

226. Safety cans which will not leak when inverted, and which are substantially constructed, should be used for local small supplies of gasolene, benzine, and similar substances.

227. Cleaning parts of machinery with gasolene is hazardous. It is possible to obtain practically as good results with kerosene, and this is strongly recommended instead.

228. Permitted appliances, passed by Underwriters' Laboratories, should be used in connection with storage or handling of inflammable liquids.

229. Insurance Requirements on the storage and use of gasolene and similar liquids are generally rigorous, and special care should be exercised to see that these are not violated.

DIP TANKS.

230. The increase in automobile manufacture in particular has greatly increased the use of dip tanks, and very large tanks (capacities up to 10,000 gallons and several in one room) are necessary. They are widely used in industries for impregnating coils, coating parts prior to japanning or enameling, and for painting in lieu of handwork. As the coating material is almost always cut with a highly inflammable solvent, the fire hazard is considerable. A special report in the 1922 Proceedings of the N. F. P. A. outlines the hazard and advisable precautions. See also page 81. Essential recommendations are:

a—Dipping room floor level to be above ground and natural drainage for heavy vapors secured to out doors.

b—Dipping preferably in detached 1-story building, or in cut-off addition, or in fire-resistive building cut off from other operations.

c—Storage of supplies and handling to accord with principles set forth in previous sections of the Handbook.
d—Electrical equipment to be fully protected against spark hazard; possible ignition in lower stories to which vapors might flow must be considered; no belts to be used; all metal to be tied together and grounded; rubber soled and heeled shoes worn by workmen.
e—Overflow pipe and automatic opening drain to accord with tank capacity (3″ for 500 gallons to 8″ for 4000 gallons).
f—Automatic covers provided for all tanks, except that on large tanks approved automatic foam extinguishing system may be substituted.

231. Present rules also cover Quenching Tanks, containing hardening and tempering oils, Flow Coat Method of applying paint, and Paint Spraying and Spray Booths. All these rules warrant careful study.

DRY CLEANING.

232. Volume 15 of the N. F. P. A. Quarterly contains much valuable data regarding the dry cleaning hazard. An analysis of 130 fires shows 84.6% due to the presence of inflammable liquids. 36 explosions and the loss of 9 lives are recorded. The ignition cause is unknown in 52.4% of the cases, but, based on later experiences, it is probably static electricity in a majority of instances. The principal known causes are: matches, 10%; static electricity, 6.9%; stoves and furnaces, 6.9%; pressing irons, 5.4%; sparks, 5.4%. In five fires, sprinklers were present, and they controlled the fire.

233. Methods of reducing fire risk where inflammable liquids must be used include:

a—Segregation of hazardous operations, with no openings for vapors to spread to points where fires or sparks may exist.
b—Care in disposing of waste cleaning liquids.
c—Grounding of all apparatus, and provision of conduit wiring with vapor-proof globes and outside switches and fuses. Motors should be in a cut-off section. See page 37.

d—Exercising great care in lifting goods out of washers; machine should stand five to ten minutes after power is shut off to dispel static charge, and care must be exercised to avoid static from the body.
e—Introducing moisture into the air in dry weather.
f—Use of automatic closing covers on washers.
g—Providing foam extinguishers or engines, or carbon tetrachloride, or powerful steam jet systems.

234. A mixture of approximately 50% gasolene and 50% carbon tetrachloride is practically safe from a fire standpoint, and can be used effectively for cleaning fabrics and metals. The objection lies in the materially higher cost of carbon tetrachloride, the difficulty of getting employes to make proper mixture, and maintaining the mixture at a safe point continually.

SEWERS.

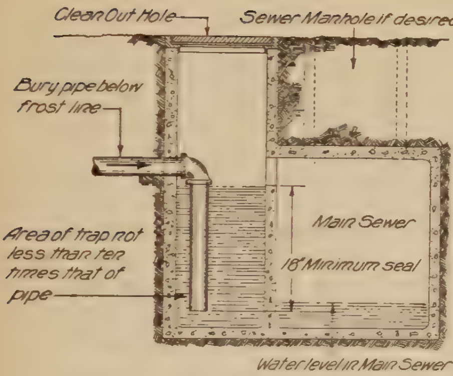
235. Disastrous explosions have been caused in public and private sewers, because of volatile liquids getting into them and being ignited. Safety precautions in connection with sewers include:

a—If possible, having sewers into which volatile liquids might run separate from plant sewers, and discharging to safe point, preferably under water.
b—Having each connection provided with a deep trap of a design making it unlikely that an explosion on either side will blow out the contents of the trap and let fire flash through, as well as preventing liquids lighter than water from flowing into sewer. See Fig. 18.

REFRIGERATING SYSTEMS.

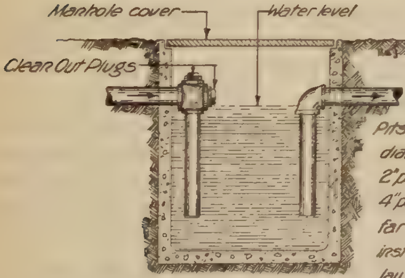
236. Fire hazard would be expected to be absent in an ammonia refrigerating system, but a considerable number of fires and explosions have taken place. The conclusions based on observations of accidents and on check tests indicate that:

a—The life hazard due to the breaking or leaking of ap-


Clean Out Hole
Sewer Manhole if desired
Bury pipe below frost line
Main Sewer
Area of trap not less than ten times that of pipe
18" Minimum seal
Water level in Main Sewer

NOTE:- Explosions in Main Sewer cannot drive Fire into Branch pipe because of large volume of water in trap which would first have to be driven into Branch pipe.

DESIGN FOR TRUNK SEWERS OF LARGE SIZE



Pits to have the following minimum diameters or equivalent areas:- 2" pipe-2'-0" pit; 3" pipe-2'-6" pit; 4" pipe-3'-0" pit. Keep pipes as far apart as possible. In some installations, to prevent freezing lay pipes in a Manure trench or aside of Steam pipes.

DESIGN FOR TRAPS FOR USE WITH PIPE SEWERS
(Showing Elbow and Cross fitting arrangements)

FIG. 18. TRAPS FOR SEWERS
(Courtesy of Independence Bureau)

paratus, and the release of ammonia fumes, even where fire does not take place, is so serious that the best of conditions and care is warranted in such installations.

b—Lubricating oils should be of the highest flash test practical from an operating standpoint, be used sparingly, and be kept out of system to as large an extent as possible through the use of an oil separator in the discharge side of the compressor.

c—Naked flames have been the direct cause of explosions where ammonia gas, usually believed to have contained vaporized lubricating oil, reached the flames. The possibility of breaking up of some of the ammonia into hydrogen and nitrogen, and an explosion resulting from the violent chemical reaction of the hydrogen with the oxygen in the air, seems fairly well established.

d—Ammonia fumes corroding exposed electrical contacts, causing an arc, and being ignited, are claimed to have been the cause of certain serious explosions. In another case, water short circuited an oil switch and the resulting arc caused an explosion of an ammonia and air mixture.

e—Testing a system with air is only permissible if oil is first removed from the entire system, and if care is exercised to avoid overheating air. After test, air can best be removed by putting system under high vacuum.

237. Ethyl chloride, methyl chloride, and propane, all inflammable, are reported used in some small refrigerating systems. An ammonia system for dwellings using gas heat for expansion would appear to have considerable inherent risk.

238. Carbon dioxide systems are safer both from a fire and an accident standpoint. The operating objection to carbon dioxide systems is the necessary higher compression. Sulphur dioxide is now being used in household refrigerating systems, and is virtually free from dangers in so far as fire is concerned.

METAL POLISH.

239. Metal polishes ordinarily consist of a solvent, such as gasolene, benzine, or naphtha, and an abrasive powder, such as whiting. The fire hazard is that of any other volatile inflammable liquid, and the danger is intensified because few people recognize the danger. Non-combustible polishes and pastes are on the market, and these alone should be used. The cost is about the same and, although these polishes as a rule are a trifle less rapid, the additional safety warrants the added effort.

SPONTANEOUS COMBUSTION.

240. In painting, wood finishing, and similar trades, spontaneous combustion is so common that the danger is generally appreciated by plant managements. Fires in soft coal are also common, but the varieties of products in which spontaneous combustion is possible is astonishing. Spontaneous combustion is charged with 9.23% of all known fires and ranks fifth as a fire cause. It is somewhat mysterious to the layman how fire can originate without the application of flame or spark or high temperature. Spontaneous combustion is "slow burning," e.g., oxidation at a rate slow compared to burning wood, but rapid when compared to drying paint or oil becoming rancid. It requires a combination of conditions to carry spontaneous heating, which is a wide spread phenomenon, to the combustion point. Certain oils, for example, oxidize much more rapidly than others; too much oil on fibres slows up action; cotton is far more dangerous than wool; moisture up to a certain point assists combustion; the size of the mass bears on heat being retained and causing the action to speed up; solar or artificial heat aids combustion, etc.

241. Vegetable and animal oils, spread over fibres, especially cotton, are always to be feared. Hay, straw, hemp, jute, cocoa fibre, fertilizers, and similar materials are subject to self-ignition, especially if oily or moist. Heat generally accelerates self-ignition.

242. Charcoal and lampblack are exceedingly dangerous. See "Fire Dangers of Steam Pipes," page 72.

243. Cork dust, linoleum in course of manufacturing, certain dyed goods, inky cloths, and saltpeter sacks cause fires.

244. Finely divided metals, such as magnesium, potassium, sodium, and zinc, because of their ability to break up water and set hydrogen free, may cause serious explosions. Even iron filings, borings, or turnings with oil and moisture may heat dangerously. See also " Dusts " on page 106.

245. The answer to a large part of the spontaneous combustion problem is immaculate housekeeping, and immediate, safe disposal of waste, rags, and other oily materials. For moderate amounts of dangerous substances, as a supply of lamp black or hazardous pigments, a metal barrel with cover is the answer. When large quantities of dangerous materials, as jute, are involved, well-constructed warehouses, moderate fire areas, automatic sprinkler protection, scuppered floors, and protection against factors that could start or speed self-ignition are advisable.

COAL.

246. Of all the substances subject to spontaneous combustion, the most important economic loss undoubtedly is suffered in connection with bituminous coal. Stored in the open, in buildings, or in holds of ships, it may ignite; the difficulties ot extinguishment generally are great; the loss frequently runs into very large sums. The chemical composition of coal varies greatly, and the presence of free gases, the presence of sulphur in the form of pyrites, size of particles, method of piling, depth of piling, length of storage, temperature conditions, moisture, and foreign combustible substances, all bear on tendency to heat and ignite. While some coals are virtually free from hazards, the only absolutely safe storage is under water and this is seldom practical. As long as the temperature does not exceed 125° F., no danger exists, but it is stated that once 150° F. is reached, the temperature will not recede.

While it is a well-known fact that certain kinds and sizes of coal are dangerous and others less so from a spontaneous combustion standpoint, other economic conditions control the coals purchased, and a purchaser and storer of coal in large quantities is therefore as a rule in one of two positions: he knows he has dangerous coal and he must safeguard its storage, or he fears his coal may fire and he wants to take reasonable precautions. Precautionary measures of approved merit include:

a—Clean up the ground where pile is to be made, and see that no foreign material gets into the pile. Avoid storing on top of sewer or steam pipe manholes.

b—Avoid dropping the coal a great distance as this breaks it up.

c—Limit the area of piles to prevent fire undermining large quantities. If storage area is not adequate for separation of piles, concrete division walls across a coal field will answer.

d—Deposit coal in layers (by opening buckets slightly, and spilling each bucketfull over a considerable area). This reduces voids and prevents fire traveling under a pile. Where conical piles are made, the larger pieces of coal run down the pile and create an "open layer" which forms the base of the growing pile.

e—Hold down the height as much as storage areas will permit.

f—Avoid alternate wetting and drying of coal during process of piling.

g—Introduce into piles at intervals of 15 to 20 ft. pipes ½″ to 1″ in diameter into which maximum thermometers can be lowered to take temperatures at various depths. A temperature of 150 deg. F. generally indicates trouble. The use of automatic heat alarms (thermostats) has been suggested. Ventilation of a pile adequate to prevent dangerous heating is hardly practical.

h—Use special temperature recording (or target to indicate higher temperature) devices and institute systematic inspection service. When coal smokes, it is generally too late to head off trouble.

247. Once a pile is threatened by fire, moving of endangered coal is almost always the remedy. Wetting down is only effective if water can be gotten to the seat of the fire. The use of carbon tetrachloride has been reported both successful and unsuccessful in extinguishing coal fires. The burying in the pile of carbon dioxide steel gas bombs, released by rising temperature, and cooling the coal by evaporation has been suggested by an English authority.

EXPLOSION HAZARDS.

248. Explosion hazards in industrial plants, other than those of inflammable liquids, are due to:

a—Explosives.
b—Dusts.
c—Gases.
d—Mechanical Ruptures.

Each topic is treated briefly in the following sections:

EXPLOSIVES.

249. Large storages of explosives are generally very well safeguarded, but many plants carry a moderate stock of dynamite and detonating caps for construction purposes. There is a tendency to consider a box or two of dynamite as unobjectionable in a general storehouse or in an oil house. A separate storehouse or box at a remote point is always advisable, and it is especially important that detonators, which are far more sensitive than dynamite, be kept separate from the dynamite. Frozen dynamite is exceedingly dangerous, and any plant that uses dynamite, even if only occasionally and in small quantities, should have a standard hot water thawing box. Fire heat should never be used.

250. The private fire brigade should know where explosives are stored. For extended treatment of the subject see publication of the Bureau of Explosives of the American Railway Association of New York, and the suggested ordinances of the National Board.

DUSTS.

251. The N. F. P. A. in 1922 published an authoritative book on dust explosions by David J. Price and Harold H. Brown, of the United States Department of Agriculture. It covers the theory of dust explosions, analyses of past explosions, the results of tests, and the structural, operating, and maintenance precautions essential to safety of life and property. In this book the authors present the following table:

NUMBER OF ESTABLISHMENT AND VALUE OF PROPERTY IN DUST PRODUCING INDUSTRIES

Industry	No. of Establishments		Value of Products	
	1919	1914	1919	1914
Aluminum manufactures	84	37	$69,474,000	$19,597,000
Chocolate and cocoa products not including confectionery	48	36	139,258,000	35,713,000
Coffee and spice, roasting and grinding	794	696	304,740,000	150,749,000
Cooperage	1,100	1,259	88,267,000	50,017,000
Cork, cutting	62	52	16,282,000	7,875,000
Fertilizers	599	784	278,610,000	153,196,000
Flour mill and grist mill products	10,714	10,788	2,193,007,000	877,680,000
Fuel, manufactures	11	14	1,974,000	863,000
Glucose, starch	56	89	186,256,000	52,615,000
Lumber, planing mill products, not including planing mills connected with saw-mills	5,314	5,841	560,867,000	307,672,000
Malt	55	97	39,340,000	48,133,000
Oil and cake, cotton seed	713	882	570,213,000	212,127,000
Oil, linseed	26	25	120,638,000	44,883,000
Oilcloth and linoleum floor	21	18	52,673,000	17,602,000
Paper and wood pulp	714	718	794,350,000	332,147,000
Phonographs and graphophones	167	18	158,668,000	27,116,000
Rice, cleaning and polishing	86	59	90,038,000	23,039,000
Soap	352	371	317,067,000	127,942,000
Sugar, beet	85	60	149,156,000	62,605,000
Sugar, cane	202	181	57,741,000	21,635,000
Sugar refining not including beet sugar	20	18	730,987,000	289,399,000
Totals	21,045	22,011	$6,919,606,000	$2,862,605,000

252. In all these industries there is a proved dust explosion risk. The property and life loss have been heavy. The finest structures have often suffered the worst losses, as witness the Northwestern Elevator disaster in Chicago, in March, 1921, where the largest elevator in the United States, splendidly built and equipped. was partly wrecked with the loss of six lives and the destruction of approximately four million dollars worth of property. In 1919. in Cedar Rapids, a starch factory explosion cost 43 lives and over three million dollars.

253. The list of industries is not complete; practically every finely divided organic or metallic substance, properly mixed with air, is subject to explosion upon contact with a spark or flame. Safety measures include:

a—Design of building and equipment least likely to permit dust to lodge. Smooth inside walls with framework outside, and with sloping fillets to shed dust are examples of this.

b—Design of dust producing equipment to permit minimum leakage of dust, and to avoid choking or clogging.

c—Installation of dust removing system, applied particularly at points of dust production.

d—Regular and frequent cleaning of the building and equipment, with special care, however, that cleaning up dust does not produce an explosion due to naked lights or sparks in vicinity. A case is on record where 9 out of 10 men who were cleaning up a coal mill died of burns produced by a flash in coal dust.

e—Unusual precautions as to ordinary fire hazards, smoking, and the carrying of matches, and special safeguards as to static electricity, hot bearings, foreign materials, etc.

See also N. F. P. A. 1923 Proceedings for dust explosion hazards and their control.

GASES.

254. See page 42 for certain phases of gas hazards. Explosions are occasionally caused by the ignition of mixtures of air with gases in cellars, attic spaces, blast pipes, stoves, furnaces, ovens, boiler settings, and generally where gas can accumulate mixed with air and be confined enough or be large enough in volume to exert violent force when ignited. The proper procedure obviously is to prevent leakage, to provide adequate ventilation, to avoid accumulation of gas and air mixtures, and to eliminate sources of ignition.

MECHANICAL RUPTURES.

255. In most plants explosions due to mechanical ruptures can result from the failure of:

Steam Boilers or other Steam Vessels.
Flywheels, Engines, and Turbines.
Tanks under Pressure.
Tanks or other Containers of Chemicals.
Grinding and Polishing Wheels.

256. Any of these may result in fire or in breakage of sprinkler system or other fire fighting equipment, and consideration must be given to such dangers if a comprehensive study of fire hazard is to be made.

FILM HANDLING AND STORAGE.

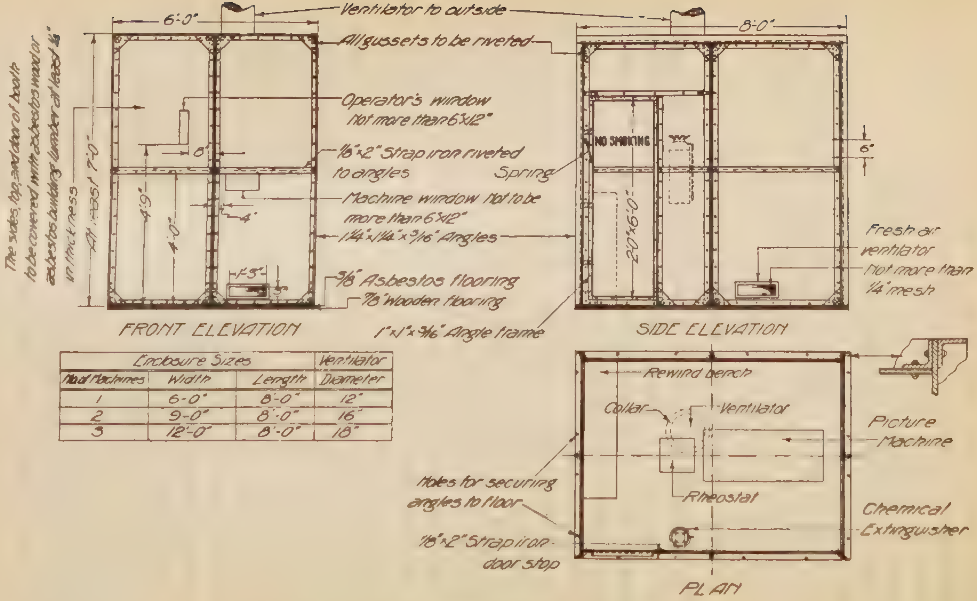
257. The great development of the motion picture industry has introduced the hazard of the storage and handling of flammable nitrocellulose films to a remarkable degree. Already a number of disastrous fires, accompanied with life loss, have shown the hazard which exists, particularly in film exchanges where repairing and testing is done. The National Board has regulations governing the production, storage, and handling of nitrocellulose motion picture films.

258. Underwriters' Laboratories have approved forms of slow-burning (acetate base) films, but while this is practical from an operating standpoint, it will never be widely used until there is a general legal requirement to this effect. In Paris, France, no highly inflammable film is to be permitted after January 1, 1925, the motion picture industry having had several years in which to prepare for the transition.

259. In properties to which comes an occasional reel or two of film, it is essential that the fire hazard of films be understood by all who handle them, that film be stored at a safe point, handled with maximum care, and especially that it be kept away from open flames. A high pressure steam pipe can ignite inflammable films; fire is intense and difficult to extinguish.

260. Tests by Eastman Kodak Company have demonstrated that fires in film vaults can be controlled by automatic sprinklers if closely spaced and provided with adequate water supplies.

261. Only motion picture machines passed by the Underwriters' Laboratories and provided with all practical safeguards should be purchased.


6'-0"
Ventilator to outside
8'-0"
All gussets to be riveted
The sides, top, and door of booth to be covered with asbestos wood or asbestos building lumber at least ⅛" in thickness
At least 7'-0"
Operator's window Not more than 6"x12"
8"
⅛"x2" Strap iron riveted to angles
Spring
NO SMOKING
6"
4'-9"
4'-0"
Machine window Not to be more than 6"x12"
4"
2'0"x6'-0"
1¼"x1¼"x3/16" Angles
1'-3"
3"
⅜" Asbestos flooring
⅞" Wooden flooring
Fresh air ventilator Not more than ¼" mesh
FRONT ELEVATION
1"x1"x3/16" Angle frame
SIDE ELEVATION
Rewind bench
Collar
Ventilator
Picture Machine
Rheostat
Holes for securing angles to floor
⅛"x2" Strap iron door stop
Chemical Extinguisher
PLAN

Enclosure Sizes			Ventilator
No. of Machines	Width	Length	Diameter
1	6'-0"	8'-0"	12"
2	9'-0"	8'-0"	16"
3	12'-0"	8'-0"	18"

FIG. 19. STANDARD METAL MOTION PICTURE BOOTH.

262. Fig. 19 illustrates the construction of a standard moving picture machine booth.

MATCHES.

263. "Matches—Smoking" ranks first as a fire cause, 13.62% of all loss being attributed to it. It is quite certain that the match end of this combination is responsible for the bulk of this combined loss. The annual consumption in the United States is placed at more than 7,000,000,000 cigars, 42.000,000,000 cigarettes, and 2,500,000,000.000 matches. No wonder that life and property loss are high. The match further is probably the principal cause of life loss, deaths to children being particularly frequent from this cause. The chief remedy is obviously care in the use of matches and especially in the disposal of used ones.

264. Strike-on-the-box safety matches are almost free from serious objections and do not cost more per hundred than the ordinary type. Where there is a possibility of boxes being carried away, they can be placed upon small holders, from which they can only be removed by breaking the box. It is generally considered good policy to furnish employes with safety matches even at the risk of many being carried away.

265. The leading manufacturer of matches, under the careful supervision of the Underwriters' Laboratories, makes labeled matches of the strike on the box and the tip types. Both are far superior to the ordinary product found on the market, and labeled matches only should be purchased. A match is not a safety match because the seller claims it. Many of the imported matches have weak, unimpregnated splints, and decidedly low ignition temperatures.

SMOKING.

266. The smoking hazard is acute chiefly because of the use of matches, although cigars, cigarettes, and pipes, themselves may cause fires if left in contact with combustible materials. The wooden clothes locker is especially objectionable for this reason. The worst factory disaster in our history, the Triangle Waist Company fire, in which 145 per-

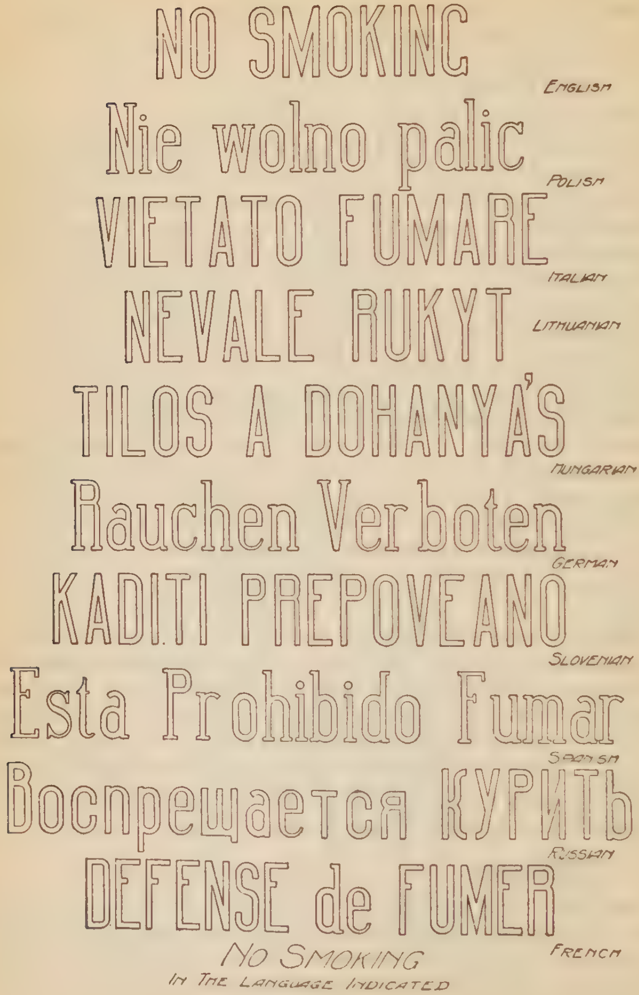


FIG. 20. "NO SMOKING" SIGNS.

sons perished, the worst hotel fire in recent decades, the Windsor, in New York, where 45 were burned to death, and numerous gigantic property losses have been charged to the careless smoker. The epitome of recklessness was reached in a Jersey City Warehouse where two employes who were handling chlorate of potash, and knew it to be dangerous, smoked at work. One man threw his cigarette butt on the floor and ground it under his heel. The resulting explosion and fire caused a widespread loss aggregating two million dollars.

267. So acute is the hazard generally recognized to be that the modern tendency is to prohibit smoking even in those sections where there would be no appreciable fire risk if smoking were allowed. A general rule such as this makes for efficiency, and avoids discrimination as between departments.

268. If smoking is prohibited generally or in portions of the plant, it is vitally important that the executives set an example and scrupulously obey the plant rules and not, as is often the case, smoke while traveling through the whole property.

269. If smoking is permitted in the less hazardous sections, these can usually include boiler rooms, engine rooms (exclusive of basements), foundries, blacksmith shops, certain offices, and locker and lunch rooms.

270. "No Smoking" signs, in several languages if necessary to reach all of the men, should be posted liberally in the forbidden sections. See Fig. 20. If smoking is permitted in certain sections, signs to that effect should be posted.

LOCOMOTIVE SPARKS.

271. Sparks from locomotive stacks or coals dropped from ash pans are common causes of fire. The remedy may lie in one or more of the following methods:

a—Provision of effective spark screen in front ends of locomotives, and careful maintenance of this protection. This is particularly feasible with privately owned locomotives.

b—Placing a special spark hood over locomotive stacks while used in very dangerous sections, such as cotton storage yards.

c—Not shaking down fires, except at safe points.

d—Elimination of combustible roofing, such as shingles and boards.

e—Protection of windows, which can be opened, by permanent ⅛″ to ¼″ galvanized iron screens.

f—Keeping normally closed scuttles, doors, and other openings through which sparks could drift or fall.

g—Not permitting locomotives to enter combustible buildings, except if used for storing or repairing locomotives.

h—Keeping property free of combustible refuse, dry leaves, and dead grass.

LIGHTNING.

272. Lightning ranks sixth as a cause of fire; loss cost of 7.32% being charged against it. Everyone knows that oil tanks, rural buildings, and chimneys are struck frequently, but that the loss is so large is rather surprising. In an analysis of almost 40,000 rural district fires, 51% were found due to lightning, and, remarkable to relate, hardly one building in almost 20,000 had a good lightning rod equipment. This bears out the previously accumulated data, namely, that a properly protected building is virtually immune from loss by lightning.

273. The 1916 proceedings of the N. F. P. A. contain the approved report entitled "Suggestion for Protection against Lightning." The introductory sections of this report are:

274. Protection against lightning is usually advisable on country buildings, on isolated buildings, and on all buildings wherever located having elevated features such as tall chimneys, steeples, high peaked or gable roofs, and flag poles.

275. Since the amount of protection which any building should have will depend upon its location, construction, nature of its occupancy, and the value of the building as compared with the expense necessary to provide the protection, definite rules cannot be laid down for the installation of lightning conductors, but the following general suggestions should, if carried out, give, under most conditions, reasonable protection.

276. The ordinary condition causing a lightning discharge is a cloud charged with electricity at a greatly different potential from that of the earth. The difference of potential is finally sufficient to "break down" the stratum of air between earth and cloud, and an electrical discharge takes place. The resistance of the air stratum being generally less between cloud and tops of buildings and other structures than between cloud and earth, such high points takes the discharge, and unless some less resistive path is provided from these points to the ground than the structure to be protected, the lightning will follow the next best course to earth, generally causing damage to the structure and frequently starting a fire.

277. It is also of importance to note that the discharge leaves a column of heated air between earth and cloud. This hot air column may be blown in one or another direction and very likely become the path of a second discharge, since it has less resistance than the surrounding cooler air. This may account for lightning striking a structure below the high points.

278. It is therefore desirable to so locate the conductors forming the lightning protection that the lightning will strike these and be carried to earth instead of tearing through the structure on its way to the ground. Such an arrangement of conductors suggests an enclosing cage with the bars of course considerably separated. The idea of protection is therefore a metallic cage with air terminal projections at the high points of the structure and the whole projecting cage thoroughly grounded.

279 The Technologic Paper No. 56 of the Bureau of Standards, entitled "Protection of Life and Property Against Lightning," contains important evidence of the value of lightning-rod protection and a comprehensive discussion of the entire subject. Copies may be procured from the Superintendent of Documents, Goverment Printing Office, Washington, D C.

PROTECTION OF BUILDINGS.

280. The Underwriters' Laboratories is now not only passing on lightning rod equipment, but is inspecting finished installations. Because of this fact the N. F. P A. committee report is of a general rather than of a specific character. Items of general interest include the following:

281 **Conductors** are required to be constructed of iron or copper and to be of approved types of cable, star section, tubular or other approved pattern. For copper cables the weight must be not less than 3 ounces per ft. or 187.5 lbs. per 1,000 ft. in length. For star section steel, the weight must not be less than 320 lbs. per 1,000 ft. in length, and must be provided with a protective coating of zinc or other approved material.

282 **Couplings** and **Connectors** must be of copper or brass, of substantial construction, and working upon the threaded, crimping, or clamping principle. Set screws not approved.

283. **Air terminals** must be of star section steel complying with the above requirements for conductors of that type or of copper tubing having an outside diameter of at least ⅝ of an inch and a wall thickness of not less than .032 inch or No. 20 B. & S. gauge The point at the top of the terminal should preferably be solid, terminating in a point or number of points at one end, and the other end provided with a screw cap or a dowel.

284. Ground terminals. The efficiency of a lightning conductor equipment is dependent directly upon the thoroughness with which it is grounded, and one of the following methods should be followed:

a—Connecting to underground water piping by means of brass plug screwed into pipe and rods soldered to plugs, or by putting clamps around pipes and threading rods to such clamps.

b—Connecting conductor to ground plate, buried usually at least 8′, and of 16 gauge copper about 1 yard square, buried in coke or charcoal to hold moisture.

c—Extending rods into permanently moist earth, where this can readily be reached.

GENERAL INSTALLATION SUGGESTIONS.

285. Air terminals are required on or within 2′ of all high points, such as chimneys, gables, spires, ventilators, cupolas, etc.

286. Along ridges, air terminals may not be over 25′ apart.

287. Stacks or other high points over 60′ high require two rods and two grounds. Points on stacks should be spaced about 6′ around circumference and set into a heavy band to which rods also are attached.

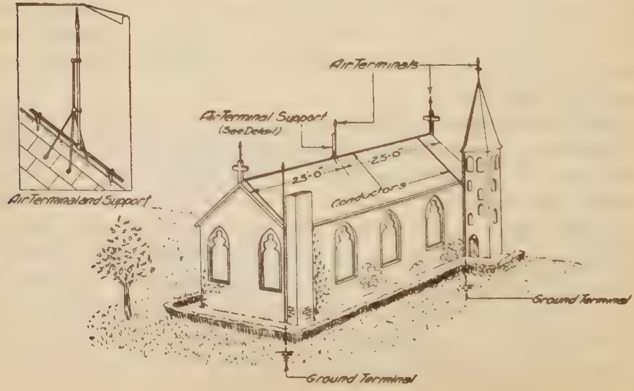


FIG. 21. PROTECTION AGAINST LIGHTNING.

288. For buildings, the minimum number of grounds is ordinarily two, and two will suffice for up to six points. Three grounds are required for twelve points, and one additional for every five points thereafter.

289 It is advisable to ground metal roofs, ventilators, piping (other than gas) which comes fairly close to outside walls, fences, clotheslines, and other metal construction.

290 Steel framework on concrete footings is not necessarily grounded, and definite grounds for such framework, for corrugated iron sheathing and for large metal tanks or other masses of metal is commonly advisable.

291. Fig. 21 illustrates standard protection methods applied to a church

PROTECTION OF OIL TANKS.

292. Oil tank protection against lightning is best secured by a combination of methods including:

a—Metal tanks with solid metal tops, gas tight.
b—Protection of all openings against admission of fire. See page 57.
c—Provision of explosion hatches to prevent rupturing of tank tops if vapors in tank are ignited.
d—Definite grounding of tanks and connecting piping.
e—Provision of foam or steam, the first to extinguish fire, the second to extinguish fire and also to fill top of tank to protect against exposure. See pages 425 and 454.

293 Elaborate caging plans have been tried as a protector to important tanks, and, speaking generally, probably without success commensurate with the cost. High masts on the storm side of tank farms have also been erected, but it is believed that the best results follow where the individual tank is safeguarded in the manner indicated.

CHAPTER 8

DANGEROUS SUBSTANCES FOUND IN MANUFACTURING PLANTS

By WILLIAM D. GRIER*

1. The writer has attempted to classify dangerous substances found in manufacturing plants as far as possible according to the hazards involved, believing that this is the most effective method of presenting the information. There are a great many inflammable or explosive chemicals which are not mentioned in this article, but as they are not very liable to be found in large quantities, and many of them not outside of laboratories, it has been thought unnecessary to mention them specifically.

2. The accident hazards of many of the substances referred to herein exceed their fire danger, and the two subjects must be considered together.

3. STRONG ACIDS—The three strong acids sulphuric, nitric, and hydrochloric, are not in themselves inflammable nor are they supporters of combustion. Their chief hazard lies in the danger of leakage and possible mixture with other chemicals which may be stored in the vicinity, which would be followed in some cases by a fire or explosion. Nitric and hydrochloric acid are capable of bursting carboys or other containers if overheated, owing to the pressure of gas evolved. Nitric acid will sometimes ignite sawdust, straw, or other packing material in case of leakage. In general strong acids should be stored in cool places away from the sun and not in proximity to other chemicals or waste material.

4. SULPHUR—Sulphur is highly inflammable and when ignited burns fiercely, but is not subject to spontaneous ignition except sometimes when mixed with other chemicals. It should be stored in a cool place away from boilers or open fires and not in immediate proximity to other chemicals. Sulphur grinding and, in fact, any handling of sulphur, tending to create more or less sulphur dust, is hazardous in the extreme as in most cases the conditions for a dust explosion are present.

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*General Agent, North British and Mercantile Insurance Company.

5. **PHOSPHORUS**—Phosphorus is very inflammable and liable to ignite spontaneously. It should always be stored under water.

6 **CHLORINE**—Chlorine is a heavy, greenish, poisonous gas given off in some manufacturing processes and by bleaching powder or chloride of lime, especially in the presence of strong acids. It it not inflammable itself but may cause fires or explosions, especially if it comes in contact with ammonia, turpentine, or finely powdered metals. Care as to ventilation should be observed in any process where this gas is generated.

7 **CHLORATES, NITRATES, PEROXIDES**—These substances are all hazardous owing to the quantity of oxygen which they evolve when heated. Most of them can be detonated or exploded when in contact with such materials as starch, sugar, gum, sweepings or dust, or other organic matter, or sulphur and its compounds. Some peroxides, notably sodium peroxide, are especially hazardous in that they become dangerously hot in the presence of moisture and are very liable to ignite any inflammable substance with which they may be in contact.

8. **METALLIC SODIUM, POTASSIUM, ALUMINUM, MAGNESIUM, IRON BORINGS AND TURNINGS, ZINC DUST, BRONZE POWDER,** or any other finely powdered metal.—These metals are all more or less hazardous in the presence of moisture, especially zinc dust, and should always be kept in dry places. A number of finely divided metals if moist will decompose water in their oxidation and set free hydrogen gas. Metallic sodium and potassium take fire in the presence of water, and are generally kept under the surface of kerosene.

9 **NITRO CELLULOSE** and its compounds in the form of Pyroxylin Plastics, Lacquers, Films, etc.—The prepara-

tion, storage, and manufacture of articles from these products is hazardous in the extreme and special precautions should be taken. They should not be stored in large quantities except in specially arranged, non-combustible storehouses, detached from other buildings. See also Chapter 7, page 109, Film Handling and Storage. See National Board regulations entitled "Storage and Sale of Pyroxylin Plastic."

10. INFLAMMABLE GASES—Special precautions as to ventilation, safeguarding of electrical devices, ventilating fans, or places where friction or electric sparks could occur should be taken. In the case of acetylene, the requirements of the National Board of Fire Underwriters should be strictly followed. See also Chapter 7, pages 42 to 50.

11. HYDROGEN GAS—Hydrogen gas is given off freely in certain chemical processes and in many electro-chemical processes, as by storage batteries. Explosions have occurred from battery gas, although the hazard is not generally severe.

12. COMPRESSED GASES—Ammonia, oxygen, hydrogen, carbonic acid, or even air when under compression should be stored in dry, cool places, as a comparatively slight rise in temperature causes a very considerable increase in pressure, which can readily occasion a violent explosion. In the case of ammonia, firemen would be unable to enter the premises until the gas has been dissipated, unless equipped with gas helmets. See page 49, Compressed or Liquid Gases.

13. VOLATILE SOLVENTS—The relative hazard of the various liquids generally classed under this head varies greatly, depending to a large extent upon the flash point or temperature at which they begin to give off inflammable vapor, and to a lesser degree on certain other physical characteristics, such as the density of the vapor and its explosive range in mixtures with air.

14. The most commonly found solvents that fall in class 1 of the National Board classification (flashpoint below 25° F. (—4° C.) closed cup test) are in the relative order of their hazards ether, carbon bisulphide, gasolene, naphtha, and benzol.

15. In class 2 (flashpoint above class 1 and below 7.0° F.

(21° C.) closed cup test) fall acetone, alcohol, amyl acetate, and toluol.

16. In spite of their relatively low flashpoints the hazards of a number of inflammable vapors seem to be much less than would be expected, especially if used in open rooms and at ordinary temperatures. With processes involving heating of inflammable liquids or with drying operations where solvents are evaporated, the hazard is much greater. Wherever inflammable liquids are handled, the maximum of care is advisable. Readers are referred to page 94, Gasolene and Other Inammable Liquids.

17. CREOSOTE AND DEAD OIL—Creosóte and dead oil, used for impregnating wood, manufacturing roofing compounds, etc., vary greatly in their composition, some being almost as inflammable as kerosene, while others are almost non-inflammable. In general, care should be taken in any process which involves the heating of these materials with fire, especially with a view to preventing leakage or boiling over.

18. COAL TAR DERIVATIVES—Coincident with the outbreak of the World War and the cutting off of foreign dyes and medicines, upon which we have been so largely dependent, began the development of a real American industry in this field. Prior to that time, our activities in coal tar derivatives had been limited largely to the production of "crudes," so called, such as benzol, toluol, naphthalene, and anthracene. Today, on an increasing scale, we are producing "intermediates," such as nitro-benzol, aniline, beta naphthol, and the long list of products bearing technical names, such as H acid, Gamma acid, and Schaeffer acid, names which mean practically nothing to the layman. From these, finished products such as dyes, medicines, and explosives are manufactured.

19. As was to be expected, the rapid development of new industries involving the use of hazardous crude materials and producing more or less dangerous intermediates and finished products resulted in a considerable number of fires and explosions, accompanied by loss of life as well as property damage. The foundation of specific experience that makes for excellent fire control in standard industries was missing at the outset, but today is fairly well established.

20. The preliminary processes of distilling the coal tar for separation into three or four principal factions are well known and need no description here. The further preparation of the "crudes," such as benzol, toluol, and other liquid products, presents a severe hazard, being on a par with the distillation and refinement of any other volatile and inflammable liquid.

21. The properties of the various crudes are well known and, as far as the liquids are concerned, the same precautions used in the storage of gasolene, benzine, and similar inflammable liquids should be observed.

22. The preparation of the intermediates, and indeed the finished products, can be classified in a well defined series of five operations, which are typical of factories of this nature. These are sulphonation, alkaline fusion, nitration, reduction, and alkylation. In addition to these processes or operations, those common to other chemical plants, such as distillation, filtration, drying, powdering, etc., will be found, together with one extremely hazardous process, namely, the washing of certain finished products with benzol or gasolene and the subsequent drying of the washed crystals.

23 In the following brief process descriptions the use of chemical terms has been avoided in so far as possible.

Sulphonation.

24. This is carried on usually in closed vessels, heated by steam, and is effected by adding oleum or fuming sulphuric acid to the substance which is to be sulphonated, the chemical effect being the replacement of certain atoms with corresponding atoms or molecules of sulphonic acid SO_3H. Hazards are frequently in the handling of the raw materials, which may possibly be benzol or some similar inflammable liquid, possibly the bursting of the sulphonating vessel, and the possible faulty arrangement of the oil heating device.

Alkaline Fusion.

25. This is carried on in open vessels or in closed vessels, sometimes under very high pressures, heated by oil bath or direct fire, and the process consists of the fusion of some substance with caustic soda, which results in the hydrolyzing of the substance operated upon, or replacing the sulphonic acid group SO_3H by the hydroxyl group OH. The hazards are not severe, and mostly refer to the method of heating.

Nitration.

26. In this process the substance to be nitrated is treated with a mixture of strong nitric and sulphuric acid, sometimes in a closed, sometimes in an open, vessel, which usually has to be cooled by water circulation, as during the nitration considerable chemical heat is developed. This might not only spoil the product, but might produce something entirely different from that desired or lead to an explosion. The location and methods of this process should be carefully observed and noted. The chemical process of nitration is to substitute nitro group NO_2 for certain molecules of hydrogen, and the process has been mostly met with in the past in the preparation of a limited amount of nitrobenzol and, to a considerable extent, in the manufacture of nitrocellulose for use in the manufacture of pyroxylin plastics, lacquer, and smokeless powder. It is met with in the manufacture of nitrobenzol and in the preparation of trinitrotoluol, familiarly known as TNT, for use as a high explosive.

Reduction

27. The chemical purpose of this process is to abstract certain molecules of oxygen, and its principal application is found in the preparation of so-called aniline oil from nitrobenzol, by treating the latter in closed vessels with metallic iron in the from of borings or turnings in the presence of hydrochloric acid. The oxygen in the nitrobenzol is taken up by the iron which is thrown away as waste product. The hazards are not serious and are easily controlled.

Alkylation.

28. This is a rather complex process, the purpose of which is to introduce methyl or ethyl groups into the formulae. It is carried on by acting upon proper substances to be alkylated with methyl or ethyl alcohol and hydrochloric acid, and the hazard, as may be supposed, is largely in the use of the alcohol.

29. There are numerous variations upon these fundamental processes, and sometimes one, sometimes all, are employed at one time or another in the manufacture of the finished product. The hazards are not obscure and are largely confined to the following features:

a—Inflammable character of raw material.
b—Method of heating, especially in the use of fire heat, and possibly defective oil circulating systems.
c—Possibility of explosion of closed steel and cast iron vessels, frequently under very heavy pressures and high temperatures.
d—Possible explosive or inflammable nature of the finished product.

High Explosives.

30. Trinitrotoluol (TNT), as stated under "Nitration," is a direct product of toluol, this "crude" being subject to three nitrations. Although it is undoubtedly the safest high explosive when finished, its manufacture is attended with considerable risk during nitration, storage of intermediate products, and crystallization with inflammable solvents. Several serious explosions in the United States have demonstrated this. The industrial poisoning hazard in intermediate stages also requires careful attention.

31. Picric acid (trinitrophenol) is made by nitrating phenol (carbolic acid), which in turn is made synthetically from benzol, employing processes of sulphonation, alkaline fusion, distillation, etc. From picric acid, picric salts, chiefly ammonium picrate, are made also for use as explosives. The manufacture of picric acid is apparently less hazardous than that of TNT, but the finished product is more sensitive to ignition, especially when heated and subject to shock. Picric acid drying requires isolation and great care.

CHAPTER 9

TOPICAL LIST OF FIRE CAUSES

1. The topical List of Fire Causes covers in skeleton form the main points appearing in Chapter 7, Common Fire Causes, and also the leading special hazard industries. From its first presentation, this boiled down method of listing the essential manufacturing processes and their fire hazards has proved a great convenience to the man in the field and to the man passing on plans of proposed new construction. The use of the list insures against overlooking any important unusual dangers, it can be used as a report outline on special hazards, and it constitutes a guide to study both before and after examination of a plant.

2. The fire records where quoted are taken from the publications of the National Fire Protection Association, the most authoritative source of information, and cover known causes only. "Misc. S. H." denotes "Miscellaneous Special Hazard" fires.

COMMON FIRE CAUSES

LIGHTING.

SUNLIGHT.

3. **Burning Glass.** Paper weights; bowls; bottles; bubbles in glass. **Spontaneous Combustion.** Oily material; coal.

ELECTRICITY.

4. **Generators.** Same as motors. Rotation in safe plane. Crane blocks against connections. **Switchboards.** Incombustible construction; covered oil switches; oil switches in compartments; flame-proof wires. **Switches.** Poor contacts; exposed to metals. **Oil Switches.** Overloads, short circuits, and insufficient oil are fire causes; individual cells. **Transformers.** Overloads, breakdown of insulation, water in oil, and lightning are fire causes; oil draw-off; location in cells.

Lightning Arresters. Over-charging; location in cells or separate buildings. **Fuses and Circuit Breakers.** Breakers set too high; fuses too large and abused; renewable fuses approved. **Circuits;** mechanically protected where necessary; joints; supports; moisture; fumes. **Temporary Wiring.** Likely to become permanent; remove dead wiring. **Motors.** Exposed to moisture, dust, fumes, gases, inflammable flyings; encased motors with outside air intakes safer; exposed contacts; drip pans. **Incandescent Lamps.** Hazard in show windows, closets, lockers, bins; guards generally advisable; keyless sockets best; incombustible shades. **Vapor Proof Fittings.** Protection against weather, fumes, dusts, vapors. **Arc Lights.** Hot carbons dropping; inflammable flyings. **Domestic Electrical Devices.** Adequate circuits; oversized fuses; portable cords. **Electric Pressing Irons.** Acute hazard; pilot lights; bracket shelves to support. **Electric Soldering Irons.** Cords; pilot lights; supports. **Portable and Pendent Cords.** Defective and dry insulation; tying aside; danger of shock.

Signaling Circuits. High tension crosses; protectors with ground. **Radio and Wireless.** Careful wiring; lightning switch; clear of other circuits. **Static Electricity.** In solids, liquids, gases; eliminating belts; grounds; humidity.

GASES.

5. City, town, or retort. Movable gas jets; combustible material near flames; loose tips; leaking connections; rubber tubing; bridging meter where electric wiring; main shut-off valves; supports for meters; lead pipe meter connections; quarter-in-slot meters. **Gasolene Gas.** Five Underwriters' classifications for machines; underground storage and carburetor safest; flare-lights dangerous. **Acetylene Gas.** Explosion danger greatest of commercial gases; compressed gas unabsorbed over 15 lbs. dissociation danger; liquid acetylene violently explosive. **Acetylene Generators.** Location; naked lights; freezing. **Oxy-acetylene Systems.** Permitted generators; pressure tanks; oxygen generaton. **Compressed or Liquid Gases.** Legal pressure limits; relief valves; safety plugs; reducing valves; outside storage and protected against sun.

OILS.

6. **Lamps.** Metal fonts; daylight filling; cleanliness; heat shields; hanging. **Lanterns.** Metal fonts; fonts dropping; safety type. **Battery Lamps.** Advisable for watchmen where inflammable vapors. **Kerosene Pressure Systems.** Supply tanks located outside; piping protected against injury. **Kerosene Torches.** Danger where combustible surroundings.

POWER GENERATION.

BOILER ROOMS.

7. Construction; cut-off; boiler settings; ash handling; soft coal; shaving vaults; cleanliness.

STACKS.

8. Outside best; if through roof ventilated sleeve; boiler uptakes; sparks.

COAL.

9. Spontaneous combustion danger; storage outside boiler rooms.

PULVERIZED FUEL.

10. Pitch; bituminous coal; three systems; pulverizing; transmission of powdered fuel; lodging of dust.

FUEL OIL.

11. Four methods of storage; power system; domestic system; storage tank safeguards; piping; valves; feed to burners; air pressure systems.

SHAVING VAULTS.

12. Location; construction; fire doors; cyclones; direct fuel feed.

STEAM ENGINES.

13. Steam pipes against wood; wood lagging; fly wheel pits.

ELECTRICAL.

14. Type of apparatus; wiring; controls; dangerous locations; wood supports; grounding.

PRODUCER GAS.

15. Location; suction type safer; carbon monoxide poisoning.

GASOLINE ENGINES.

16. Location; supply tanks; piping; ignition; mufflers; exhaust piping.

GAS ENGINES.

17. Location; gas bags; ignition; mufflers; exhaust piping.

KEROSENE ENGINES.

18. See gasolene engines.

SELF IGNITION ENGINES.

19. Oil pressures; inside oil tanks; exhaust piping.

WATER POWER.

20. Bearings; cleanliness; naked lights.

POWER TRANSMISSION.

BELTS.

21. Against wood; static electricity; leather more dangerous; belt shifters.

ROPE DRIVERS.

22. Against wood; grease and dirt.

SHAFTING AND BEARINGS.

23. Bearings overheating; shafting alignment; maintenance; cleanliness.

PULLEYS.

24. Slipping belts; slipping pulleys; construction.

HEATING.

CHIMNEYS AND FLUES.

25. Construction; supports; thickness; clearance of wood.

STEAM.

26. Conditions causing fires; support and insulation of piping.

HOT WATER.

27. Very mild hazards in piping; boiler hazard.

HOT AIR.

28. Intakes; blower location and cleanliness; steam coils; ducts; dampers; dwelling furnaces; hot air pipes.

RANGES.

29. Types; floor protection; back well protection; smoke pipes; hoods, vent pipes, and flues.

COAL AND WOOD STOVES.

30. Types; floor protection; back wall protection; smoke pipes.

FIREPLACES.

31. Construction; hearths; screens.

ASHES.

32. Storage; mixed with refuse.

GAS STOVES.

33. Types; supports; protection of wood; piping; flue connection.

PRESSING IRONS AND HEATERS.

34. See "Electrical" above; see "Gas Stoves" above.

35. Gas heated irons; supports, tubing; shut-offs.

GASOLENE STOVES.

36. Type; filling.

KEROSENE STOVES.

37. Far safer than gasolene.

ELECTRIC HEATERS.

38. Types; supports; wiring; overheating; burns and shocks.

ALCOHOL STOVES.

39. Spilling alcohol; combustible surroundings; solid fuel.

FORGES AND FURNACES.

40. Types; locations; protection of wood; piping; ashes; indicating lights; gas and air piping.

PORTABLE FORGES AND FURNACES.

41. Pressure tanks; tank trucks; piping; hose; relief and shut-off valves; points where used.

JAPANNING AND ENAMELING OVENS.

42. Types; source of heat; locations; explosion hazards.

SALAMANDERS.

43. Type; combustible surroundings; asphyxiation; supervision.

SAND DRYERS.

44. Non-combustible surroundings; steam piping; stoves; stove piping.

TORCHES.

45. Gasolene; kerosene; alcohol; leaks; burning off paint.

HOUSEKEEPING.

REGULAR CLEANING.

46. Organization; facilities; baling presses for waste; inspections.

OILY MATERIALS.

47. Common kinds; storage; disposal.

CLEAN WASTE.

48. Principal supplies; local supplies.

DRIP PANS.

49. Metal; motors; machines; maintenance.

PACKING MATERIAL.

50. Common kinds; storage; special protection.

LOCKERS AND CUPBOARDS.

51. Metal; wood; sprinkler protection; maintenance; inspection.

BLOWER SYSTEMS.

52. Heating and ventilating; stock; refuse; blower construction and location; ducts; dampers; vents; cyclones; dust disposal.

OILS AND PAINTS.

LARGE STORAGE.

53. See "Fuel Oil" above; above ground; retaining walls; underground; pits.

OIL HOUSE.

54. Construction; oil handling; extinguishing apparatus; heating; lighting; ventilation.

INSIDE OIL ROOM.

55. See "Oil House" above.

PUMP TANKS.

56. On wheels; local supply; good practice.

LOCAL SUPPLIES.

57. Amounts; containers; supports.

GASOLENE AND OTHER INFLAMMABLE LIQUIDS.

FIRE HAZARDS.

58. Classified according to hazards; fire record.

STORAGE AND HANDLING.

59. Underground tanks; pumps; hydraulic systems; air pressure systems; pump tanks on wheels; safety cans; substituting kerosene.

DIP TANKS.

60. Location; construction; capacity; storage of supplies; overflows; automatic covers; room ventilation; naked flames; spray booths.

DRY CLEANING.

61. Fire record; segregation; static; humidity; foam extinguishers.

SEWERS.

62. If possible, separate for volatile liquid wastes; traps.

REFRIGERATING SYSTEMS.

63. Ammonia life and explosion risk; lubricating oils; naked flames; testing; carbon dioxide, and other systems.

METAL POLISH.

64. Non-combustible types far preferable.

SPONTANEOUS COMBUSTION.

65. Vegetable and animal oils; agricultural products; charcoal; lampblack; organic dusts; metal dusts; coal especially discussed.

EXPLOSION HAZARDS.

EXPLOSIVES.

66. Storage; frozen dynamite; fire brigades posted.

DUSTS.

67. Industries affected. Kinds; building design and arrangement; equipment design; removal; special hazards.

GASES.

68. Conditions under which explosions take place; leakage prevention; ventilation; ignition sources.

MECHANICAL RUPTURES.

69. Types of apparatus; fire hazards; crippling fire fighting equipment.

FILM HANDLING AND STORAGE.

70. Slow burning films; legal regulations; storage; projecting booths; projecting machines; sprinkler control.

MATCHES.

71. Parlor; tip; safety; safety box holders; furnishing to employes; labeled matches.

SMOKING.

72. Generally inadvisable; where reasonably safe; to apply to all persons; foreign language notices.

LOCOMOTIVE SPARKS.

73. Locomotive spark screens; stack spark hoods; handling locomotive fires; incombustible roofing; window screens; not entering hazardous buildings; cleanliness.

LIGHTNING.

74. Theory of protection; conductors; couplings and connections; air terminals; ground terminals; general installation suggestions; oil tanks.

SPECIAL FIRE CAUSES

ACID WORKS.

75. Furnaces, Pyrite Burners—Construction and arrangement. **Stills or Condensers**—How arranged. **Niter and Niter Bags**—Where stored. **Sealing and Packing**—Where done.

Principal Hazards—Strong hydrochloric and nitric acids will attack and ignite fibrous material and must be handled carefully. This is the chief hazard other than the furnaces and burners.

AGRICULTURAL IMPLEMENT FACTORIES.

76. These risks contain to a certain extent the hazards of both wood and metal workers, to which reference can be made.

Principal Hazards—Large dip tanks, generally without proper protection. Painting and varnishing, including oily rags. Also such wood-working hazards as lumber dry kilns and sawdust vaults.

ASPHALT WORKS.

77. See Roofing Paper Works.

AUTOMOBILE FACTORIES.

78. These frequently include the various hazards of wood and metal workers. **Painting and Varnishing**—Where done. Storage and handling of materials. Oily rags. **Japanning**—Storage and handling. How thinned. Japan ovens, how heated and arranged. **Engine Testing**—Handling, storage, and use of gasolene. **Gasolene.** Used for cleaning. Air pressure sprayers.

AUTOMOBILE GARAGES AND REPAIR SHOPS.

79. Gasolene. How stored and used. Open cans. Filling of cars. Air pressure spraying. Used for cleaning metal parts. **Kerosene** or other substitutes for cleaning. **Forge** or other open flame furnaces. **Fuel.** Where located. **Soldering Irons.** How heated. **Oily Waste.** Supply of cans.

Principal Hazards—Careless use and handling of gasoline; automobile filling.

Fire Record—Gasolene fires outside of automobiles, but including filling, 48%; automobiles (including carbureters, 10%), 19%; repairing and vulcanizing, 10%; miscellaneous special hazards, 2%; common hazards, 21%.

BAKERIES.

80. **Grinding.** Sugar or starch. Arrangement of starch room. Any liability to dust fire or explosion. **Ovens.** Construction. Arrangement. Fuel used. **Doughnut Making.** Arrangement of kettles. Fuel used. **Flour Elevators and Cleaning.** Liability to dust fire or explosion. **Dry Rooms.** How heated and constructed. **Paper or Wooden Box Making.** Printing. Where done. **Benzine Tin Smithing.** Soldering machines. **Bisulphide of Carbon** used as preventative of insects. Where stored and used. **Gasolene.**

Principal Hazards—Ovens, Doughnut Kettles, Dryers.
Fire Record—Bake ovens, 31%; ignition of grease, 15%; miscellaneous special hazards, 4%; common causes, 50%.

BICYCLE FACTORIES.

81. See Metal Workers.

BLEACH, DYE, AND PRINT WORKS.

82. **Singeing.** Location and construction of room. Cut-off. Method of heating. **Chemicals.** Where stored. How cared for. Lime, chlorates, benzol, naphtha, peroxide of sodium. **Turkey Red Dyeing.** Construction of ageing and drying room. **Aniline Black Dyeing.** Chlorates used. Oxidizing room. **Printing.** Chlorate used for oxidizing. Cloth dry room. Cleaning of rollers.

Principal Hazards—Singeing machine and fire in cloth after leaving machines. Use and storage of chlorate of potash. Dry rooms or boxes. Spontaneous combustion of dyed goods after drying or aging, especially black goods.

Fire Record—Singeing, 17%; drying, 15%; chemicals, 11%; spontaneous ignition of dyed goods, 10%; napping, 5%; miscellaneous special hazards, 11%; common causes, 31%.

BREWERIES AND MALT HOUSES.

83. **Elevators.** Construction and care. **Kilns.** Location and construction. Fuel. Cut-off. **Malt Roasters.** Type. Fuel. Malt cooled thoroughly before placing in bins. **Malt Mill.** Construction. Location. Magnets over rollers. Grain cleaned before reaching mill. Conveyors. **Feed Dryers.**

Construction and arrangement. **Brew Kettles.** How heated. **Vat Varnishing.** Kind of varnish used. Where done. **Pitching of Kegs.** Where done. How is pitch heated. **Coopering.** Where done.

Principal Hazards—Pitching of barrels and kegs, and ignition of pitch due to defective heating arrangements. Poorly constructed malt kilns. Malt grinding.

Fire Record—Barrel pitching, 17%; malt mills, 10%; malt kilns, 5%; miscellaneous special hazards, 10%; common causes, 58%.

BRICK AND CLAY WORKS.

84. **Drying.** Location and arrangement of dry rooms. How heated. Iron racks. **Kilns.** How constructed and arranged. Fuel used. Combustible material nearby. **Forming Machines.** Oil used. **Packing Material.** Where stored. How cared for.

Principal Hazards—Poorly constructed kilns. Careless use of packing materials.

BROOM FACTORIES.

85. **Bleaching.** Ovens. How arranged. **Gluing.** Pots. How heated. **Painting and Varnishing.** Where done. **Woodworking.** If any, where done.

Principal Hazards—Uncleanness.

BRUSH FACTORIES.

86. Similar to broom factories but not as dirty.

CANDY FACTORIES.

87. **Cooking Furnaces and Kettles.** Location. Construction. Floors. Flues. Fuel. **Roasters.** For cocoa beans or nuts. How arranged. **Bench Stoves.** Kind. Where used. Fuel. **Steam Tables.** Kept clean. Free from woodwork. **Starch Room.** Grinding. Ventilated. Accumulation of starch dust. Open lights. Dryers. **Sugar Pulverizers.** Where located. **Dusters or Sifters.** Location. Arrangement. **Dry Room.** Steam or fire heat. Steam pipes properly arranged and kept clean. **Dipping.** Alcohol or other inflammable dip used.

Principal Hazards—Poor construction and arrangement of cooking furnaces or kettles. Dry Room.

Fire Record—Sugar mill, 10%; candy boiling, 8%; cocoa grinding and roasting, 13%; dry rooms, 3%; miscellaneous special hazards, 14%; common causes, 52%.

CANNING FACTORIES.

88. **Cooking and Kettles.** How heated and arranged. **Soldering Cans.** Arrangement and location. Gasolene used. **Glue or Paste Pots.** How heated. **Varnishing.** How done and how is varnish handled and stored. **Refuse.** How cared for.

Principal Hazards—Poor care of heating hazards combined with uncleanly conditions.

CAR HOUSES (ELECTRIC).

89. **Pits.** Construction and care. Used for storage or accumulation of refuse. Communicating with each other. **Oils.** Where stored. Oil lamps used and where filled. **Repair Work.** Painting, woodworking, machine shop, oily waste, armature baking ovens, forges, glue pots. **Electrical Hazards.** Defective car power wiring, heating, or lighting, trolley poles left on wires. **Car Stoves.** Safely arranged. Ashes, how cared for.

Principal Hazards—Most serious fires start inside the cars from defective wiring or from stoves. General repair work adds considerably to the hazard of a car house.

CARPET YARN AND WEAVE MILLS.

90. See Woolen Mills.

Fire Record—Picking, 30%; stock fires, 17%; carding, 16%; drying, 8%; dusting, 3%; miscellaneous special hazards, 13%; common causes, 13%.

CARRIAGE AND WAGON WORKS.

91. These risks partake of the hazards of both wood and metal workers, to which refer.

Principal Hazards—Poor arrangement of forges, with combustible material nearby. Painting and oily rags.

Fire Record—Forging, 10%; woodworking machines, 7%; painting, 6%; oily rags, 4%; miscellaneous special hazards, 19%; common causes, 53%.

CEMENT PLANTS.

92. **Raw Stock Drying.** Type of cylinders and how heated. Stacks, how arranged. **Coal Pulverizing.** Grinding mills. Type and location. Location and arrangement of dryers.

How heated. Pulverized coal, where stored. **Kilns.** Type and method of heating. Woodwork nearby. **Conveyors.**

Principal Hazards—Ignition of coal dust at grinding mills or dryers. Woodwork near furnaces.

CEREAL MILLS.

93. **Dusters or Cleaning Machines.** Dust collectors. Dust room. Type of cleaning machine. Magnets. **Dryers.** Type. Where located. How heated. **Aging.** Location of electric ozone machine. **Grinding.** Type of machine. Magnets.

Principal Hazards—Grinding machines. Dryers.

Fire Record—Conveyors, 16%; dryers, 21%; grinding, 37%; cleaning, 11%; common causes, 16%.

CHEMICAL PLANTS.

94. The hazards vary greatly in this industry. A study of the processes and materials used is necessary in order to arrive at even a fair understanding of the fire hazard.

Fire Record—Ignition of chemicals, 33%; explosion, 12%; inflammable vapor, 5%; grinding, 6%; drying, 4%; miscellaneous special hazards, 11%; common causes, 29%.

CLOTHING FACTORIES.

95. **Waste Clippings.** How cared for. Where stored. **Sad Irons.** Type and method of heating. Iron stands. Control of gas. Flexible tubing used. Arrangement of stoves. Charcoal used or stored. **Waste Chute.** Location and construction.

Principal Hazards—Overheated sad irons igniting bench or combustible material due to gas or electric current being left turned on. Accumulation of waste material (under benches and around shafting).

Fire Record—Waste Material, 22%; sad irons, 25%; miscellaneous special hazards, 5%; common causes, 48%.

COOPERAGE WORKS.

96. **Sawdust.** How cared for. Blower system. Feed direct to boilers or to vault. Automatic dampers. **Sawdust Vault.** Construction. Location. Cut-off. Openings to same from outside. **Dry Kilns or Rooms.** Construction. Location. How heated. Steam pipes or blower system properly arranged. Blower cleaned and well oiled and cared for. **Barrel Drying.** Location. Method of heating. **Barrel Storage.** Location. Piled, how high.

Principal Hazards—Dry kilns. Sawdust vault and fuel in front of boilers. Barrel drying.

Fire Record—Dry kilns, 21%; sawdust vaults, 17%; barrel drying, 8%; common causes, 54%.

CORDAGE WORKS.

97. Stock. Where stored. Kind of stock used. **Pickers or Breakers.** Where located. Care of waste material. **Oils.** Kind used. How fed to machine. **Tarring.** How heated. Where used. Main supply stored. **Dryers.** How heated. Kept clean. Steam pipes properly arranged.

Principal Hazards—Storage of jute stock. Foreign material or hot bearings in pickers and cards.

Fire Record—Pickers (inc. openers, etc.), 37%; carding, 30%; drying, 4%; miscellaneous special hazards, 13%; common causes, 16%.

COTTON MILLS.

98. Stock. Where stored. Amount opened at once. **Openers, Pickers, and Lappers.** Location. Cut-off. Lighting. Picker trunks protected. **Dust Room.** Location. Dust flue. **Stock Conveyors.** Between what rooms or buildings. Location of blower and method of stopping. Automatic devices or dampers. Stock fed direct from machine or into hopper by hand. **Card Room.** Location. Lighting. **Napping.** Location. Dust, how conveyed away and where. **Dryers.** Type. Method of heating. **Waste.** Where stored.

Principal Hazards—Openers or pickers, fire caused by foreign material in stock. Open lights or electric short circuits in picker and card rooms where accumulations of cotton fly. Stock conveyors cause fire due to friction or sparks, and fire may be blown from one building to another.

Fire Record—Openers, pickers, and lappers, 52%; spinning and fly frames, 13%; miscellaneous special hazards, 21%; common causes, 14%.

COTTON WAREHOUSES.

99. Compress. Boilers cut off. Compress cut off. Cleanliness. **Bales.** Kind. Stored on end or side. How high. Capacity of sections in bales or cu. ft. **Outside Storage.** Amount. Covered with tarpaulins. Spark exposure; source and distance. **Miscellaneous.** Smoking allowed on premises. Sources of fire. Office stoves and ashes. Stables. Storage of chemicals. Temporary lighting.

Principal Hazards—Poor housekeeping, sparks, smoking, boilers.

Fire Record—Cotton bale fires, 48%; sparks from gin, 4%; spontaneous combustion, 3.5%; common hazards, 26%.

COTTONSEED OIL MILLS.

100. Cleaning Machines. Location. Dust blown where. Blower separator. **Linters.** Sand screen and magnets before reaching linter. Condenser and feeders. Construction. Cut-off. Accumulations of lint and dust. Lint baled where. **Hull House.** How are seeds conveyed to hull house. Crushers. **Heaters.** Steam. **Oil.** How conveyed to storage tanks. Location of tanks. **Press Clothes.** Material. Dried how and where. Stored after drying. **Cake Grinding.** Location of mill. Type. **Hulls.** Conveyed to boiler for fuel.

Principal Hazards—Accumulations of lint and dust in cleaning and linter rooms, and sparks at linter due to foreign material.

Fire Record—Linters, 23%; huller, 14%; gin, 11%; seed and hull houses, 10%; conveyor systems, 7%; seed cleaning, 3%; miscellaneous special hazards, 10%; common causes, 22%.

DEPARTMENT STORES.

101. The modern department store has a multitude of special hazards, among which are the following: laundries, dry rooms, repair work, upholstering, painting and varnishing, restaurants, excelsior and packing, special decorations, waste chutes and vaults.

Fire Record—Waste chutes and vaults, 15%; kitchen stoves, 4%; irons, 3%; miscellaneous special hazards, 8%; common causes, 70%.

DISTILLERIES (also see GRAIN ELEVATORS).

102. Bone Black and Charcoal. How stored. **Corn Shellers.** Location. Ventilation. **Corn Oil.** Cake grinding. Dry rooms. **Malt Mills.** Magnets. Blowers. **Malt Kilns.** Construction. How heated. **Stills.** Where located. **Denatured Alcohol.** Where done. Storage and handling of wood alcohol, benzine, or other denaturing compounds.

Principal Hazards—The hazards of the distillery are chiefly those of the grain elevator or malt mill and not the distilling processes.

DRUG RISKS.

103. Compounding. Use of heat or stoves, boiling or cooking of inflammable compounds. Gas stoves. **Storage and Handling of Chemicals.** Amounts and where stored. Nitrates. Chlorates. Peroxide of sodium. Metallic sodium or potassium. Anodyne. Picric acid. Carbon disulphide. Ether. Alcohol. Phosphorus. Collodion. Amylacetate. Acetone. Nitrobenzol. Benzine, naphtha, gasolene, or benzol. See Chapter 8, Dangerous Substances Found in Manufacturing Plants.

Principal Hazards—Compounding and boiling over or igniting of inflammable compounds being heated on coal or gas stoves.

Fire Record—Ignition of chemicals, 15%; ignition of volatile liquids, 15%; compounding, 13%; drug grinding, 9%; dry boxes, 7%; miscellaneous special hazards, 2%; common causes, 39%.

FERTILIZER FACTORIES.

104. Acid Plant. Pyrites burners. Arrangement of Glovers Tower. **Nitrate of Soda and Niter Bags.** Where stored. Niter bags removed from premises. **Raw Stock Storage.** Spontaneous ignition of animal matter and tankage. **Phosphate Plant.** Kilns and dryers. How arranged and heated.

Principal Hazards—Storage and handling of raw stock. Niter bags. Pyrites burners.

FLOUR MILLS.

105. Cleaning Machines. Location and type. Dust collectors. **Dust Room.** Location and construction. **Heaters or Conditioners.** Construction and arrangement. Method of heating. **Smut Machines.** Location. Cleaned out frequently. **Bran Dusters.** Location. Type. **Bisulphide of Carbon.** Used for killing insects.

Principal Hazards—Lack of cleanliness and accumulation of dust. Hot bearing, open light, or other ordinary fire hazard may cause explosion of flour dust.

Fire Record—Spontaneous combustion of stock and dust explosions, 12%; conveyors, 4%; grinding, 8%; cleaning machines, 4%; miscellaneous special hazards, 1%; common causes, 71%.

FOUNDRIES.

106. Cupola Furnaces. Roof nearby covered with noncombustible material. Platform and supports of iron. Combustible material near cupola. **Melting Furnaces.** Construction and location. Combustible material nearby. Flues properly arranged. Ceiling. **Flasks or Moulds.** Where stored after using. **Core Ovens.** Construction and location. Fuel used. **Charcoal.** Where stored.

Principal Hazards—Sparks or heat from cupolas igniting roof or loading platform. Hot metal or castings igniting combustible material.

Fire Record—Cupolas, 36%; melting furnaces, 13%; core ovens, 9%; molding and casting, 12%; miscellaneous special hazards, 12%; common causes, 18%.

FUR HAT FACTORIES.

107. Dusters. Location. Dust blown where. **Stiffening.** Denatural alcohol, where stored and used. Amount inside factory. Location of stiffening room. Open lights. **Drying.** Location and arrangement of dry room. Method of heating. Slatted floors over boilers. Clean. **Alcohol Reclaiming.** Type of machine. Location and arrangement. **Finishing Irons.** How heated. Slug furnaces or stoves. Fuel. **Lure Stoves.** How heated and arranged. Woodwork protected. **Singeing.** Gas flame, naphtha, kerosene. Main supply naphtha stored where. **Steam Tables.** Properly arranged. **Dryers.** How heated and arranged.

Principal Hazards—Use of alcohol, especially in the reclaiming process. Lure stoves ignite woodwork or combustible material on bench. Dirty-dry rooms.

GAS WORKS.

108. Generators. Combustible roofs. Combustible platforms or floors. **Retorts.** Combustible roofs. Combustible floors or platform. **Oil Tanks.** Screened vents. Shut-off valves. Retaining walls. **Oil Pumps.** Cut-off. Pressure regulators. **Oil Piping.** Connections screwed. Pressure relief valves. Exposed to breakage. **Tar Fuel.** Pump feed. Cut-off pump room. **Tar Seals.** Deeper than pressure relief. Combustible material in vicinity. **Sewers.** Trapped connection to each building. Covered. **Purifiers.** Seals. Open lights. Hose connections for purifier box fires. **Oxide.** Mixed on wood. Revivified on wood. Stored too close to buildings. **Governor.** Seals. Open lights. **Holders.** Serious exposure. Oil on outside of seals. **Pentane.** Lamps filled near lights. Stored where. **Electrical.** Vapor-proof globes and outside cutouts where gas danger.

Principal Hazards—Escaping gas. Oil fires.

GLASS WORKS.

109. Kilns and Furnaces. Melting furnaces. Annealing ovens or leers. Blow furnaces. Glory holes. Flattening ovens. Pot furnaces. Range ovens. Location, construction, arrangement, combustible material at safe distance. Flues. Fuel used. Oil heating 'system. **Dryers.** Sand or emery. Construction and method of heating. **Packing.** Accumulation of straw or other packing material.

Principal Hazards—Defective furnaces with woodwork nearby, open lights, and packing material.

GLUCOSE AND STARCH WORKS.

110. Elevators. Wooden or metal legs. Self-cleaning tops. Arrangement of chutes and spouts. **Cleaning Corn or Grain. Drying.** Arrangement of dry rooms. Liability to dust explosion. **Grinding Starch.** Liability to dust explosion. **Converting.** Process used. Any nitric acid used. **Drying and Grinding Gluten.** Type of machines used. Location. **Corn Oil Manufacturing.** Process used. **Char Kilns.** Arrangement of same and handling of bone black or charcoal. **Sulphur Burning.** Arrangement of burners. Storage of sulphur. **Coopering, Box, or Bag Making.** Where done.

Principal Hazards—Starch grinders. Dryers. Char kilns.

GLUE FACTORIES.

111. Boiling and Evaporating. Kettles, how heated. **Residuum Drying.** Type of dryer. How heated. Construction of chutes. **Sulphur Burning.** Location and construction of ovens. **Drying.** Location and arrangement. Construction. How heated

Principal Hazards—Poorly arranged dry rooms with steam pipes against woodwork.

GRAIN ELEVATORS.

112. Smut and Brush Machines. Type and location. Dust, how disposed of. **Dust Room.** Location and arrangement. **Corn Shellers.** Location. Disposal of refuse. **Feed Grinder.** Location. Type. **Dryers.** Construction. Type. Method of drying. Location. **Bleachers.** Construction. Location. Sulphur burner. Spout cut-offs. **Conveyors.** Elevator heads and boots.

Principal Hazards—Shafting out of line and hot boxes igniting dust. Dust accumulation and explosion or quick spreading fire.

Fre Record—Dust explosions, 3%; conveyors, 28%; cleaning, 3%; common causes, 66%.

GROCERIES, WHOLESALE.

(Including coffee roasters and spice grinding)

113. Coffee Roasters. How arranged and where located. Fuel. **Cleaning or Dusting.** Where done. Blowers. **Spice Grinding.** Where located. Ventilation. Magnets in feed spouts. **Glue Pots.** How heated. **Matches.** Where kept and how handled. **Kettles.** How used and purposes for which used. **Candy Making. Dry Rooms.** Location and arrangement. **Sugar Grinding.**

Principal Hazards—Coffee roasters and spice grinders are frequent sources of fire.

INSULATED WIRE FACTORIES.

114. Tinning. Tinning furnaces, how arranged and heated. **Compounds.** Storage of sulphur and lampblack or carbon. **Rubber Drying.** Location and arrangement of dry rooms. How heated. **Vulcanizers.** Location and arrangement. How heated. **Waxing.** Location. Mineral wax or paraffine used. How heated.

Principal Hazards—Use of hot wax or paraffine in large quantities. Dry rooms.

KNITTING MILLS (Full Process).

115. Pickers. Where located. Class of stock used. **Cards.** Stock used. Picked or lapped before carding. Open or closed cards. **Solder Pots.** How heated. **Dryers.** Type and location. Steam jet. **Dry Room.** Location. How heated. Arrangement of steam pipes.

Principal Hazards—Low grade cotton stock and foreign material causes frequent fires at first breaker card. Cotton or mixing pickers poorly arranged. Dirty dry boxes or dry rooms.

Fire Record—Picking, 44%; carding, 25%; miscellaneous special hazards, 16%; common causes, 15%.

LAUNDRIES.

116. Dryers. Location and construction. Type. How heated. Kept clean. **Ironing.** Ironing machines, how heated. Gasolene gas. **Sad Irons.** Type and method of heating. Iron stands. Control of gas. Flexible tubing. Arrangement of stoves. Charcoal used or stored. **Gasolene.** How stored and used.

Principal Hazards—Dryers poorly constructed of combustible material and not kept clean. Spontaneous ignition of clothes dried in rotary dryers. Gas or electric heated sad irons left turned on.

Fire Record—Dry rooms, 26%; gasolene, 10%; irons, 8%; miscellaneous special hazards, 12%; common causes, 12%.

LINSEED OIL WORKS.

117. Seed Elevators and Conveyors. How cared for. **Grinding.** Bearings. **Naphtha Process. Cookers.** Press cloth dry rooms. **Cooper Shop.** Painting.

Principal Hazards—Use of naphtha, and conveyors and bearings.

MATTRESS FACTORIES.

118. Stock Used. Kind and where stored. **Stock Dusters.** Location and arrangement. Cleanliness. Cut-off. **Pickers.** Where located. Cut-off. Class of stock used. **Garnet Machines.** Location. **Carding.** Where located. Cut-off. Class of stock used.

Principal Hazards—Low grade mixed stock and general lack of cleanliness. Pickers handling low grade stock. Garnets and cards.

Fire Record—Pickers, 49%; garnets, 10%; raw stock, storage, and handling, 8%; carding, 6%; dusters, 4%; miscellaneous special hazards, 8%; common causes, 15%.

METAL WORKERS.

119. Oils. Where stored. **Acids.** Where stored. **Oily Steel Chips.** How cared for. **Forges.** Construction. Fuel. Flues. Roof. Floor. **Fuel Oil.** Method and arrangement. **Furnaces and Mufflers.** Construction. Location. Fuel. Flues. Process. **Enameling and Tinning Furnaces.** Constructon. Location. Fuel. Flues. **Oil Tempering.** Location. Construction of room. Oil, how heated. **Japanning, Painting, and Varnishing.** Main supply stored. Where used. Amount in factory. **Dip Tanks.** Construction. Protection. Overflow. Covers. Open lights used. **Japan Ovens.** Location. Construction. Method of heating. Ventilated. **Lacquering.** Main supply stored. Where used. Amount in factory. **Lacquer Ovens.** Location. Construction. Method of heating. **Buffing.** Care of buffing dust. Blower systems. Dust, where deposited. Use of oil polish on cotton wheels. **Gas Burners, for Soldering, etc.** Fixed (not movable). Combustible material nearby. **Benzine and Gasolene** (for cleaning, etc.). Main supply stored outside. Safety cans used. **Glue Pots.** How heated. Arrangement. **Pattern Making.** Care of sawdust. Dry kilns. **Oily Waste.** How cared for. Waste cans emptied daily.

Principal Hazards—Defective furnaces or mufflers, or combustible material nearby. Japan dip tanks and ovens. Poor care of oily waste. Spontaneous combustion of buffing dust.

Fire Record—Forges and hot metal, 5%; furnaces and mufflers (including fuel oil), 11%; oil tempering, 2%; Japanning (including dip tanks and ovens), 10%; lacquering, 2%; buffing, 5%; benzine, 3%; miscellaneous special hazards, 11%; common causes, 51%.

OIL-CLOTH AND LINOLEUM WORKS.

120. Oil Boiling. Away from risk. **Compound Mixing.** Where done. Main supply stored. Benzine used. Where stored. **Coating Machine.** Location. Knives grounded to carry off static electricity. **Drying.** Construction and arrangement of dry rooms. Method of heating. **Cork Grinding.** Where done. Dust well cared for.

Principal Hazards—Oil boiling. Drying rooms or cells. Frictional electricity at coating machines.

Fire Record—Dry rooms, 30%; coating machines, 21%; cork grinding, 12%; miscellaneous special hazards, 20%; common causes, 17%.

PACKING HOUSES.

121. Cooperage. Location. Barrel furnaces or stoves. Dry rooms. **Rendering.** Location of lard department. Cut-off. Steam heat used. **Waste and Fertilizer Tanks or Dryers.** Location. Type. Fuel. Construction. **Smoke Houses.** Location. Construction. Cut-off. Grid over fires. Combustible rods or hangers. Accumulation of soot; cleaned out frequently. **Branding Irons.** How heated. **Printing or Marking Ink.** Where mixed. Material used. **Soldering Irons.** Where used. How heated.

Principal Hazards—Cooperage department. Burning out of smoke houses due to ignition of soot, or fat or grease dropping on fire. Ordinary causes make serious fires due to presence of grease and oil in large quantities.

PAINT AND VARNISH WORKS.

122. Oil Boiling. Non-combustible building and isolated. **Storage Tanks.** Location. Filling. Vents. Benzine. Alcohol. Turpentine. Oils. Method of pumping or conveying to buildings. **Lampblack.** Where kept. **Paint Mills.** Where located. How cleaned. **Rosin.** Boiling and storage. **Dryers** for colors. How heated. **Japan Varnish or Mixed Paints.** Where made and proportion of benzine. **Cooperage.**

Principal Hazards—Inflammable vapors. Color drying. Spontaneous ignition of colors or lampblack.

Fire Record—Inflammable vapors ignited, 16%; color drying, 7%; dry color grinding, 4%; rosin boiling, 9%; paint grinding, 3%; spontaneous combustion of color, etc., 11%; varnish boiling, 12%; miscellaneous special hazards, 10%; common hazards, 28%.

PAPER BOX FACTORIES.

123. Glue Pots or Paste Machines. How heated. **Waste Material.** How cared for. **Benzine.** For cleaning. **Drying.** How arranged.

Principal Hazards—Accumulation of waste material.

Fire Record—Waste paper, 9%; glue pots, 5%; miscellaneous special hazards, 18%; common hazards, 68%.

PAPER MILLS.

124. Stock. Kind and where stored. Sorting. Blower system for removing dust under benches. **Dusters.** Where located. **Rag Pickers.** Location. Cut-off. **Cutters.** Stock handled. Location. **Lime.** Where stored. Amount. **Rotary Boilers.** How arranged. Inspected. **Sizing Kettles.** How heated. **Lamps.** Sealing wax, how heated. **Shafting.** Properly cared for. **Drying.** Steam pipes properly arranged. Where done. **Waterproofing.** Processes.

Principal Hazards—Stock preparing machines handling rags, jute, or miscellaneous dirty stock. Over-heated bearings.

Fire Record—Raw stock, 23%; dusters, 10%; cutters, 3%; paper machine and ventilators over same, 7%; miscellaneous special hazards, 2%; common causes, 55%.

PICTURE FRAME FACTORIES.

125. Gilding and Finishing. Use of alcohol, benzine, shellac, varnish, etc. **Glue Pots.** How heated. **Steaming Ovens.** Steaming tables. **Dip Tanks.** Covers, overflow. **Rubbing Waste and Rags.** How cared for. **Refuse.**

Principal Hazards—Careless use of combustible liquids, and poor care of waste material.

POTTERIES.

126. Kilns. Use of fuel oil. **Dryers.** How arranged and heated. **Decorating.**

Principal Hazards—Overheated kilns and combustible material.

PRINTING, BINDING, AND LITHOGRAPHING.

127. Benzine. Where used. Amount. Main supply stored. Safety cans used. **Type of Rollers.** How cleaned. Material used. Benzine substitutes. **Waste Paper.** How cared for. **Oily Waste.** How cared for. Waste cans. **Lampblack.** Where stored and how. **Glue Pots.** How heated. **Finishing Tools.** How heated and arranged. **Varnishing.** Where done. Kind of varnish used. Main supply stored. How applied. Dryers.

Principal Hazards—Poor care of oily waste and sweepings, and carelessness in the handling of benzine. Varnishing a considerable hazard where used.

Fire Record—Oily rags, 22%; waste paper, 5%; benzine, 4%; electrotyping, 3%; photo-engraving, 2%; miscellaneous special hazards, 10%; common causes, 54%.

PULP MILLS.

128. Ground, Sulphite, or Soda Process. Sulphur. Where stored. Any combustible material in room or woodwork nearby. **Sulphur Burners.** How arranged. Location. Can burning sulphur overflow and ignite combustible material. **Digesters.** Location. Arrangement. Method of heating. **Chip Room.** Location. Cut-off. **Chip Conveyor.** Construction. Shaft bearings accessible and well cared for. **Cookers.** Location and arrangement. Any heat other than steam. **Reclaiming Furnaces.** Location. Cut-off. Fire-resistive construction of room. Arrangement and construction. Fuel.

Principal Hazards—Burning sulphur igniting woodwork. Hot bearings at chip conveyor. Soda ash reclaiming furnace.

Fire Record—(Sulphite Pulp). Chipping and chip conveyors, 23%; sulphur burning, 7%; miscellaneous special hazards, 10%; common causes, 60%.

RICE MILLS.

129. Brush Machine. Construction of brush box. Steam jet. Sprinklers. **Attrition Machine.** Location. Magnets in spouts at machine. **Paraffine.** Used. Heated. **Threshing.** Chaff, how disposed of. **Dust Room.** Location. Arrangement. Dust blown inside.

Principal Hazards—Spark at attrition machine igniting the dust.

ROOFING PAPER WORKS (see PAPER MILLS).

130. Compound Mixing. Asphalt, gums, oils, etc. Where stored and mixed. **Coating.** Coating tanks and machines. Where located. **Waste Material.** How cared for.

Principal Hazards—Inflammable compounds and uncleanly conditions.

RUBBER FACTORIES.

131. Reclaiming. Kind of stock handled. Storage of ground stock. Wet or dry process. **Dryers.** Location. Arrangement. Method of heating. Kept clean. **Spreaders.** Location. Cut-off. Where done. Varnish where mixed. Main supply stored. How handled. Amount in main buildings. **Compound.** Where mixed. Churn room. Cut-off or detached. Properly ventilated. Amount naphtha used. How is compound or rubber cement conveyed to spreading or making rooms. **Varnishing.** Where done. Cut-off. Varnish, where mixed. Main supply stored. **Heaters.** Location. Construction. Heating. Open steam jet. **Devulcanizers.** Type. Location. **Heel Presses.** How heated. **Rubber Drying.** Location. Heating. **Hard Rubber.** Bisulphide of carbon used. Where used and stored.

Principal Hazards—Spontaneous ignition of ground stock and stock being dried in reclaiming process. Use of large quantities of benzine compounds as in churn room, spreader room, varnish room, and making room, Charring and ignition of woodwork of heaters.

SHEET METAL WORKERS (see METAL WORKERS).

132. Japanning. Dryers and ovens. **Lacquering.** Care of lacquer. **Soldering.** Method of heating. **Dip Tanks.** Covers and overflow. Liquid used. **Welding.** Heat used. **Benzine.** How used.

Principal Hazards—Numerous heating hazards with open flame and inflammable liquids.

SHOE SHOPS.

133. Pasted Heels. Paste, how heated. Drying. **Cutting Board Scrapings.** How cared for. **Rubber Cement.** Main supply stored. Amount in factory. How used. Safety cans. Open lights nearby. **Naphtha.** Main supply stored. Safety cans. **Cork Filling.** Where used. Mixed with naphtha compounds. **Oil Proof,** or other compounds using naphtha. **Wax Cups.** How heated. **Alcoline** or wood alcohol. Where stored. Used for lamps for heating wax or shoe tools. **Buffing Dust.** How disposed of. **Wax Filling** for heels. How heated. **Shoe Dryers.** How heated and arranged. **Lampblack.** Where stored. **Polish Making.** Wax heated. Turpentine. **Stain or Edge Blackings.** Naphtha used for mixing or thinning. **Edge Setters.** How heated. **D. & G.** or other gasolene carbureter used. **Shoe or Kit Tools.** How heated. **Waste Chute.** Location. Construction. Doors. Discharges where. **Cement and Oil House.** Location. Distance from factory. Construction.

Principal Hazards—General and careless use of naphtha cement and other naphtha compounds. Use of oil and gas wax heaters and wax boiling over and igniting. Spontaneous ignition of cutting board scrapings.

Fire Record—Cementing, 13%; bottoming, 5%; finishing, 10%; cutting board scrapings, 6% waste chute, 3%; miscellaneous special hazards, 25%; common causes, 42%.

SUGAR HOUSES.

134. Grinding or Diffusion Process. Kettles. Open. Heating. **Cooperage.** Location. Barrel heaters. **Chemicals.** Sulphur, lime, or acids, where stored. **Bagasse Burner.** Location. Arrangement. Bagasse for fuel under boilers. **Hot Room or Dryer.** Location. Steam pipes.

Principal Hazards—Bagasse burning and poor arrangement and location of burners or boilers.

SUGAR REFINERIES.

135. Char House. Fire-resistive construction. Cut-off. **Char Kilns.** Construction. Method of heating. Location. **Bone Black.** Where cooled. **Lime.** Where stored. **Sugar Bags.** Dried in risk. Construction and location of dryers. **Boiling.** Steam heat. **Dry Rooms.** Location. Construction. Heat. **Grinding and Pulverizing.** Dust properly cared for.

Principal Hazards—Poorly constructed char kilns not cut off. Sugar bag drying.

TANNERY AND CURRY SHOPS.

136. Tannery. Bark or chemical tanning. **Bark Mill.** Location. Cut-off. "Step" well oiled and cared for. **Water Spray.** Method of conveying ground bark to leach house.

Fleshings. Where stored. **Oil and Grease.** Kind used. Amount. Where stored. Floors kept clean. **Whitenings.** How often cleaned up. Where stored. **Chemicals.** Lime, lampblack, where stored. **Drying.** Method of heating. **Patent or Enamel Leather.** Compound or daub where mixed and main supply stored. Amount naphtha used. Where is coating done. **Ovens or Dryers.** Location and construction. Method of heating.

Principal Hazards—Bark mill. Use of naphtha in making patent leather.

TOBACCO WORKERS.

(including Cigars and Cigarettes).

137. Box Making. Cigar box. Care of sawdust. Vaults. **Dryers or Dry Rooms.** Construction. Method of heating. Drying machines. **Dusters.** Dust conveyors. **Grinders.** Care of dust. **Licorice Kettle.** How heated. **Paste Pots.** How heated. Hog or scrap wood breaker.

Principal Hazards—Dryers of various kinds and dry rooms.

Fire Record—Dry rooms, 14%; hog breaker, 14%; machine dryer, 7%; miscellaneous special hazards, 8%; common hazards, 57%.

WINDOW SHADE FACTORIES.

138. Benzine for thinning and washing or cleaning. Where stored and how used. **Dip Tanks.** Covers and overflow. Where located. **Drying.** Where done. Heat. Flat or festoon. **Hand or Machine Coating. Paint Grinding.** Colors. Volatile liquids used. **Varnishing.** How done and dried.

Principal Hazards—Use of benzine in quantity. Dry rooms.

WOOD WORKERS.

139. Waste Burner. Type. Location. **Sawdust.** How cared for. Blower system. Fed direct to boilers or to vault. Automatic dampers. **Sawdust Vault.** Construction. Location. Cut-off. Openings to same from outside. **Chutes or Conveyors.** Construction. Location. **Glue Pots.** How heated. **Dry Kilns or Rooms.** Construction. Location. How heated. Steam pipes or blower system properly arranged. Blower clean and well oiled and cared for. **Caul**

Boxes. Construction. How heated. Steam pipes against woodwork. Clean. **Oils, Varnish, Fillers, Turpentine.** Amounts used. Where stored. Metal or wood barrels. How thinned. **Benzine or Naphtha.** Main supply stored. How much used and where. Open lights. **Dip Tanks.** Size. Location. Number. Construction. Automatic covers. Overflow pipes. **Oil Room.** Construction and location. **Cleaning or Rubbing Rags.** How cared for. **Excelsior.** Where used. Main supply stored. **Bending or Embossing Machines.** How heated.

Principal Hazards—Spark in shaving vault of fuel in front of boilers. Benzine dip tanks. Dry kilns. Spontaneous combustion of rubbing rags.

Fire Record (Rough Woodworkers)—Sawdust vaults and blower systems, 25%: dry kilns, 16%; miscellaneous special hazards, 4%; common causes, 55%.

Fire Record (Furniture Factories)—Sawdust vaults and blower systems, 12%; dry kilns, 12%; dip tanks, 6%; hand varnishing and finishing rags, 20%; miscellaneous special hazards, 5%; common causes, 45%.

Fire Record (Saw Mills)—Sawdust vaults, 7%; dry kilns, 14%; refuse burners, 5%; miscellaneous special hazards, 7%; common causes, 67%.

WOOLEN MILLS.

140. Rag Carbonizing. Wet or dry process. Construction and arrangement of furnace. Type and method of heating of dryers. **Stock Used.** Shoddy or rags stored where. **Oil.** Kind used on stock. Amount in picker room. **Dusters.** Location and arrangement. Cleanliness. Cut-off. **Shoddy Pickers and Gauze Rooms.** Location. Construction. Cut-off. **Mixing Pickers, Lumpers, Wool Pickers.** Location. Cut-off. **Garnet Machines.** Location. **Wool Cards.** Class of stock worked on same. Cotton used. **Stock Dryers.** Location. Construction. Method of heating. **Cloth Dryers.** Type. How heated. **Sulphur Bleaching.** Where done. Construction. Arrangement of sulphur pot. Can combustible material fall into pots or be ignited by sulphur overflowing. **Stock Conveying System.** Blower system. See Cotton Mills.

Principal Hazards—Carbonizing dryers. Shoddy pickers. Friction at card or spark due to foreign material where mixed or low grade stock used. Sulphur bleaching.

Fire Record (Shoddy Mills)—Pickers, 42%; carbonized stock dryers, 21%; garnet machines, 10%; cards, 9%; miscellaneous special hazards, 10%; common causes, 8%.

CHAPTER 10

RETARDING THE SPREAD OF FIRE

1. The following chapters deal with building construction and fire retardant equipment and are intended to serve as a guide in constructing, altering, and equipping buildings so that the spread of fire may be reduced to a practical minimum:

Chapter 11—Fire-Resistive Construction.

Chapter 12—Mill Construction.

Chapter 13—Structural Improvements for Existing Buildings.

Chapter 14—Roofs and Roof Coverings.

Chapter 15—Protection of Openings in Walls and Partitions.

In addition, the following chapters bear in part, at least, upon the broad subject of retarding the spread of fire.

Chapter 16—Building Codes.

Chapter 36—Egress.

Chapter 38—Protection of Records and Valuables.

Chapter 39—Conflagration Hazard and Protection.

2. The purpose of this chapter is to set forth certain fundamental considerations involved in retarding fire spread, and to correlate the above listed chapters.

HOW FIRES SPREAD.

3. Fires spread primarily in three ways and in the manner listed in the following divisions:

1—From floor to floor of the same building through

- A—Unprotected floor openings, such as those for elevators, stairs, dumb waiters, belt ways, chutes, and pipes, and through light wells.
- B—Fires burning through floors.
- C—Fires burning through protection provided for vertical openings.

D—External windows or other wall openings.
E—Smoke passing into upper floors and smoke explosions following.

2—From building to building (adjoining) through

A—Unprotected wall openings.
B—Failure of fire doors or other protective coverings for wall openings.
C—Lack of parapets.
D—Flashing over or around parapets and igniting combustible walls, roofs, roof coverings, monitors, or pent houses.
E—Passing from windows in one side to those on opposite side of a division wall.
F—Diagonal exposure of wall openings at right angles to each other.
G—Heat passing through walls, especially at points where timbers are let into them.
H—Smoke passing through wall openings and smoke explosions following.
I—Failure of walls through explosions, upsetting by fall of imbedded structural members, or other causes.

3—From building to building (not adjoining) through

A—Inflammable roofings.
B—Combustible cornices.
C—Overhanging roofs.
D—Unprotected wall openings.
E—Permanent or temporary openings through which sparks or brands can pass.
F—Combustible exterior walls.
G—Combustible monitors and pent houses.
H—Combustible additions, passages, or other structures.

4. In fires in individual buildings, radiated heat under still air conditions has ignited combustible building trim as much as 500 ft. distant from the fire. In conflagrations, the "hot blast" (invisible heat) traveling ahead of the fire may ignite combustible material as far as several thousand feet away.

THE IDEAL BUILDING.

5. Only the most modern buildings of certain types, such as office buildings, hotels, and schools, by the use of fire-resistive construction, metal doors and trim, and metal frame wired glass windows throughout, approach the ideal structural conditions where the amount of combustible material in any one fire area is small, the construction is such that fire in one section practically cannot spread to another, and exposure fire cannot enter the structure. Could our cities and isolated industrial plants be generally so constructed, the need of expensive fire fighting equipment would largely fall away, and conflagrations or other devastating fires would be a thing of the past.

6. No such situation exists in any city, and very few industrial plants, by reason of superior building construction and contents of low combustibility, need no attention from the point of view of retarding the spread of fire. While in many plants the existing conditions, especially if sprinklers are provided, may not warrant extensive improvements of this character, careful consideration of this subject is always in order when one or more of the following conditions exist:

a—Building construction combustible.
b—Contents inflammable.
c—External exposure present.

7. All insurance rating schedules take into account such factors as building construction, unprotected vertical openings, areas of fire sections, and exposures, and there frequently is a financial incentive to design a new plant correctly or to improve an existing one as regards fire spread.

IMPROVEMENTS FREQUENTLY NECESSARY.

8. In ordinary buildings, there is almost always an opportunity or a necessity of doing the following:

a—Protect vertical openings. See Chapter 13.
b—Treat existing walls between sections so as to secure the maximum of fire-resisting power. See Chapter 15.

c—Eliminate combustible exterior construction and attachments to important buildings that are exposed. See Chapter 13.

d—Provide protection for wall openings for important buildings badly exposed. See Chapter 15.

9. The likelihood of a serious fire in a sprinklered plant is small, as proved by experience, but it is not safe to trust alone to sprinklers to protect very large values where buildings or contents are combustible. When automatic fire fighting equipment fails and fire fighting forces cannot cope with a fire, fire walls and protected wall openings are the last line of defense. That these agencies of fire defense have been successful in a large number of important instances is a matter of general knowledge.

10. Generally speaking, a building constitutes practically no exposure to others, providing it is sprinklered, except under conflagration conditions.

11. How serious conflagration exposure to a sprinklered plant may be was demonstrated in the Salem conflagration in 1914, where the Naumkag Steam Cotton Company mill, valued at over three million dollars, was almost completely destroyed by exposure fire. No large industrial plant can be expected to have a large enough water supply and fire fighting organization to defend itself against conflagration attacking simultaneously literally hundreds of unprotected wall openings.

NEW BUILDING DESIGN.

12. In designing new plants, the modern tendency is to do the following:

a—Employ fire-resistive or incombustible construction throughout.

b—Limit fire areas where contents are combustible to 25,000 sq. ft. (the limit recommended by the National Board Building Code).

c—Protect vertical openings in buildings over one story high.

d—Provide metal frame wired glass window protection where exposure exists, and frequently as a matter of general policy because:

1—Exposure may develop later, even if not already present.

2—Floor to floor fire spread is a possibility under adverse conditions.

3—Breakage hazard is less than with plain glass.

4—Metal sash has operating advantages over wooden ones, such as remote control.

Note: Metal sash glazed with ordinary glass is far superior to wooden sash, as wood may ignite by radiated heat and thus transmit fire to the building.

e—When exposure is severe and wired glass alone may not afford adequate protection, a combination of automatic rolling shutters and wired glass is being employed. See page 242.

f—Another satisfactory combination against moderate exposure is metal sash, glazed with non-wired glass, and with automatic rolling shutters on the outside.

13. Fig. 22 illustrates a number of methods of guarding against the spread of fire through a group of buildings.

DETAILS OF METHODS OF IMPROVEMENT.

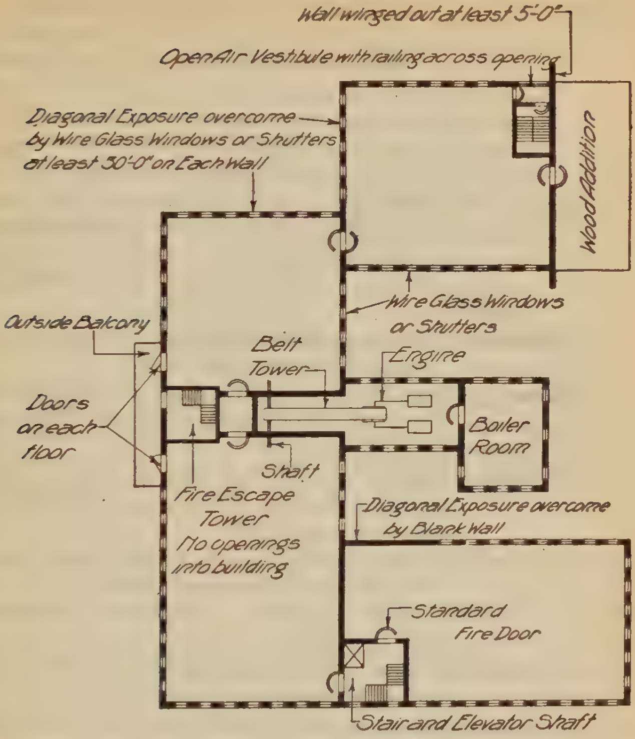
14. A consideration of the list of means by which fire may spread between floors of the same building and between adjoining buildings or those near each other will frequently suggest the proper remedies, but the following specific references and suggestions will facilitate consideration of the details of the problem.

15. The figures refer to corresponding ones in a preceding section of this chapter.

1-A. **Unprotected Floor Openings.** See Chapter 13.

1-B. **Burning through Floors.** Fire will search out unerringly any weak spot in the construction, such as thin sections of flooring, cracks between floor boards, or openings caused by shrinkage.

1-C. **Burning through Protection for Vertical Openings.** It is necessary that the materials used for protect-


Wall winged out at least 5'-0"
Open Air Vestibule with railing across opening
Diagonal Exposure overcome by Wire Glass Windows or Shutters at least 30'-0" on Each Wall
Wood Addition
Outside Balcony
Wire Glass Windows or Shutters
Belt Tower
Engine
Doors on each floor
Boiler Room
Shaft
Fire Escape Tower No openings into building
Diagonal Exposure overcome by Blank Wall
Standard Fire Door
Stair and Elevator Shaft

NOTE—All brick walls to extend at least 3'-0" above roof

FIG. 22. PLAN OF GROUP OF BUILDINGS

ing vertical openings and the devices placed upon them have fire-resisting powers at least equal to the floors, and obviously that materials and devices be kept in repair. A dumb waiter shaft fire door that is nailed in the open position may vitiate a thousand dollars worth of other fire spread protection.

1-D. **Via External Windows.** See Chapter 15. While fire may destroy approved wired glass windows in the stories in which fire breaks out (glass softens enough to fail at about 1700° F. and fires often reach temperatures over 2000° F.), it is not likely to destroy also the windows in the floors above because these are not so directly attacked.

1-E. **Smoke Explosions.** To eliminate this possibility may require, in addition to tight floors and protection of vertical openings, proper ventilation of the building by the fire department or fire brigade when it arrives.

2-A. **Unprotected Division Wall Openings.** Chapter 15 is devoted largely to this subject.

2-B. **Failure of Fire Doors.** See Chapter 15. Failure of fire doors may be due to any one of the following fundamental reasons:

a—Fire doors not on each side of wall so as to give two lines of defense and valuable air space between them.

b—Fire doors substandard as regards tinclad covering or other structural features.

c—Fire doors partially or improperly equipped with hardware.

d—Fire doors not closed, owing to lack of or failure of human or automatic action.

e—Combustible sills, door frames, or other construction close to door openings conveying fire.

f—Fire so intense that doors or hardware are destroyed.

2-C and D. **Passing Over or Around Walls.** It is obvious that where a division wall is not continued through the roof, and where roof is combustible on both sides, fire is almost certain to spread beyond the wall if the fire is of any duration. The need of complete protection against fire spread at the roof line is particularly great because the fire fighting force frequently cannot readily reach the upper floor and the roof to prevent spread of fire at that point. The following represents good engineering practice:

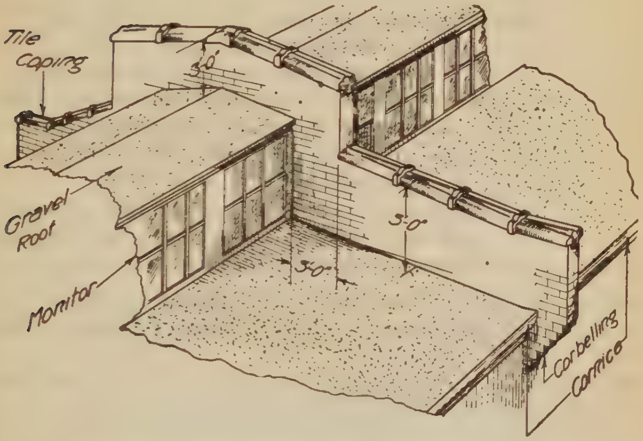


FIG. 23. STANDARD PARAPET WHERE ROOFS AND MONITORS ARE COMBUSTIBLE ON BOTH SIDES

a—Where roofs on both sides of division wall are fire-resistive or incombustible no parapet is required.

b—Where roof of one side of party wall is *fire-resistive*, no parapet is required, even if building has combustible contents.

c—Where roof on one side of division wall is *incombustible*, no parapet is required if contents cannot burn.

d—Under all other conditions, parapets must be provided.

16. Where **parapets** are provided, the following is good practice:

- a—Roofs at same level require minimum parapet of 3 ft.
- b—Where one or both fire areas are large or very combustible, parapets as high as 5 ft. and even higher may be warranted.
- c—Where monitors exist one one or both sides, proceed as shown in Fig. 23. The 3-ft. dimension may need to be increased, as covered by "b."
- d—Where roofs are at different levels, parapet 2 ft. above the higher level may be sufficient.
- e—Minimum thickness of parapet to be 12″.

17. The question of the height of parapets required is one on which the underwriters having jurisdiction should be consulted.

18. The **wing wall** illustrated in Fig. 22 shows how fires can be prevented from passing around walls. A wing wall is absolutely necessary where both buildings are frame, and desirable where one building is frame. The minimum projection should be 5 ft. in the former case and 3 ft. in the latter.

19. Overhanging roofs, if they cannot be removed, constitute a fire spread menace, even if the division wall is corbelled out so as to cut through the roof at all points. This is due more to the overhang being attacked diagonally from below than horizontally at the roof line.

20. Among the advantages of flat roofs over sloping ones is that the outer walls of the buildings can more readily be parapeted without introducing snow and rain removal problems.

21. Roof coverings and their relative fire retardant values are covered in Chapter 14.

2-E. **Passing Around Division Walls via Windows.** Fire issuing from windows near the division wall can readily, and particularly under influence of wind, sweep diagonally upwards and across the wall to the other side. For buildings of ordinary height, considerable protection is secured if the outside walls of the one building are blank for a distance of 20 ft. to 30 ft., or if windows are protected on both sides of the wall for about 20 ft. on each side. The character of construction, the height of building, and the contents are factors which bear on this point. See 1–D, above.

2–F. **Diagonal Exposure.** Fig. 22 shows several ways of treating exposure, namely, with at least one blank wall for not less than 30 ft., and with shutter or wired glass protection on both walls for an equal distance.

2–G. **Heat Passing Through Walls.** There is a case on record where a severe exposure fire so heated a 12″ thick brick wall that combustible finish on the opposite side was ignited. The minimum thickness of brick in exterior walls should be 8″, and in division walls 12″, at any point where exposure may be at all severe. With division walls, the chief weakness comes from letting floor timbers into walls on one or both sides, frequently immediately opposite. Sometimes timbers are carried through walls, sometimes they abut, and sometimes they overlap. The result is obviously fatal to good division wall conditions, partly because of the burning out of timbers and partly because of the tearing out of bricks if timbers fall.

Fig. 27, page 193, shows self releasing floor timbers set into brick walls.

To secure proper wall thickness behind timbers, they can rest on corbelled out brickwork, be supported on wall brackets, although this is not as good a method, rest on timbers bolted to the wall, or be alternately let into the wall on opposite sides.

Although in no sense of the word the equivalent of a solid brick wall as regards structural strength or fire resistance, furnace tests have shown wood studs covered with metal lath and plaster to possess fire retardant properties of at least 1 hr., which makes this form of protection a very valuable feature in many situations.

2–H. **Smoke Explosions.** A particularly serious explosion and fire causing a heavy loss in a cotton storage warehouse is attributed to a comparatively small unprotected hole admitting smoke to a section adjoining the one in which fire had broken out. The closing up of needless openings and the protection with tightly fitting doors or shutters of those which remain is the remedy.

2–I. **Failures of Walls.** To guard against failures of walls at time of fire it is obvious that new division walls should be particularly substantial. It is generally the practice to make division walls 4″ thicker than outside walls. A minimum thickness of 16″ is generally advisable. Old walls occasionally can be strengthened by repairs, and floor timbers can be made self releasing, although this is generally both difficult and expensive.

3–A. **Inflammable Roofings.** See Chap. 14.

3–B. **Combustible Cornices.** Cornices should be removed where possible. If they must remain, and if hollow, they should be stopped off at intervals of not more than 30 ft., and cut off from the inside of the building. Covering them with lock jointed tin or metal lath and plaster is a step in the right direction.

3–C. **Overhanging Roofs.** See par. 19, above.

3–D. **Unprotected Wall Openings.** See sections 1–D, 2–E, and 2–F, above.

3–E. **Sparks and Brands.** The remedy obviously is to keep closed or to protect with screens all scuttles in roofs, monitors, other ventilating openings, and even ordinary windows in buildings where the spark hazard is particularly to be feared. See Chapter 13.

3–F. **Combustible Exterior Walls.** Where wooden exterior walls are subject to exposure the means of safeguarding them, other than replacing with brick or concrete, are generally to employ outside sprinklers or hose streams. Covering wood with metal lath and plaster gives considerable protection.

3–G. **Monitors and Pent Houses.** This subject is touched on in Chapter 13. See also 2–D, above and Fig. 23.

3–H. **Combustible Additions.** Removal or cutting off is generally advisable. See Chapter 13.

CHAPTER 11

FIRE RESISTIVE CONSTRUCTION

By **JOHN STEPHEN SEWELL**[*]

1. The term "fire-resistive" has very properly replaced the term "fire-proof" when reference is made to buildings, for no material available to man for construction purposes is proof against damage by fire, unless the fire is of slight intensity and short duration. Even our kilns and furnaces yield and must be periodically re-built. But it is possible so to construct buildings that they resist fire to a very considerable extent; it is even possible thus, ultimately, to prevent great catastrophes, and to diminish ordinary fire losses so as to yield a satisfactory return upon the greater investment required.

STANDARDS OF RESISTANCE.

2. All the materials used in construction resist fire to some extent, but none of them is absolutely proof against damage by fires of the intensity often attained in experience. Existing buildings vary from the flimsy combustible structure easily ignited, to the high class building which would probably protect its contents in a conflagration, which will certainly confine a fire originating within to the unit of space in which it starts, and which, even in a conflagration, would suffer damage amounting, probably, to not more than 20% of its sound value.

3. The latter standard is very high, quite expensive, not often commercially practicable, and, therefore, rarely exemplified. A much lower standard, if universally applied, would, in the judgment of the author, completely eliminate the Conflagration Hazard, and, combined with the proper elements of an active defense, satisfy all reasonable requirements.

4. From the standpoint of attack by fire, a fire-resistive structure is nothing but a fortification; a passive resistance. No fortification in itself and apart from human activity ever decided a battle or a campaign; nor can human beings construct a building that would not ultimately yield to fire, sufficiently intense and long continued. Relatively light defensive works combined with aggressive human activity are superior to much heavier works, without it. So, the course of wisdom in this matter of reducing the fire loss, is to look well to the active defense, which is the decisive factor and should never be neglected. From this standpoint, sprinkler systems and other extinguishing apparatus, inspections, and fire prevention regulations of all sorts are part of the active defense.

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EVOLUTION OF THE FIRE-RESISTIVE BUILDING.

5. In early attempts at "fire-resistive" construction, it was considered sufficient to make the principal parts of a building of incombustible materials, and to this day the fact that "incombustible" and "fire-resistive" are not synonymous terms is not always clearly recognized. It has required long and costly experience to bring about a realization of the fact that stone, cast iron, rolled steel, and wrought iron are not fire-resistive, although incombustible under ordinary conditions.

6. In the early days of fire-resistive construction, and even to the present time, the differences of opinion as to the relative merits of various "fire-resistive" materials have been greatly accentuated by conflicting commercial interests; the result has been that the layman or novice might well be excused if he found in the state of the art even now much that is confusing and contradictory. However, enough data have now been accumulated from actual fires and from the admirable tests conducted at the Underwriters' Laboratories * and elsewhere, to enable architects and engineers to specify quite exactly the type or types of fire-resisting structure best adapted to each individual case.

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* See comprehensive report entitled "Fire Tests of Building Columns" following tests at Chicago jointly under the auspices of the Associated Factory Mutual Fire Insurance Companies, the National Board of Fire Underwriters, and the U. S. Bureau of Standards. An excellent extract appears in the October, 1921, quarterly of the N. F. P. A. See page 183.

7. Among early buildings of a monumental type are found some built almost entirely of brick work, except, possibly, the facing of the exterior walls, which is often of stone. The interior construction is all of brick bearing walls and piers, carrying arches of brick work, which support the floors. So far as resistance to an interior fire is concerned, the structural parts of such a building are as nearly fire-resistive as anything that has ever been built, or is likely to be built. But for reasons which are apparent enough such buildings are not commercially possible, and will not be further considered.

8. Other early buildings have had brick bearing walls, cast iron floor beams, and brick floor arches. Sometimes in the interior of such buildings, brick piers or cast iron columns have served to support cast iron girders, which in turn carried the beams and floor arches. With improvements in the processes of making wrought iron and steel, rolled shapes took the place of cast iron, and then speedily followed the evolution of the type of building in which the floors are carried entirely by a skeleton or frame composed of steel columns, girders, and beams. Sometimes the exterior walls of such buildings carry themselves from the foundations up, and sometimes they, as well as the interior partitions, are carried, story by story, on the metal frame work; but, in any case, the walls of such buildings are nothing but curtains and have no structural duty to perform, except that required to hold themselves in place.

9. Economy of steel led to the development of various types of floor slabs and arches which are lighter than brick arches; of these the hollow terra cotta arches, the gypsum (plaster of paris) reinforced slabs and arches, and the reinforced concrete slabs and arches are the principal types. In the development of the reinforced concrete building, girders, beams, and floor slabs came first, followed by interior columns, then by a complete frame-work, and finally by the use of exterior walls, where architectural considerations have not required the use of other material.

10. The popularity of the reinforced concrete building is well deserved, and, while the structural design is probably not on the same high plane as that of steel frame building, the failure of finished buildings is exceedingly rare, and of those under construction almost equally so.

NECESSITY OF PROTECTING STRUCTURAL MEMBERS.

11. At first, no attempt was made to protect metal structural members from fire. Cast iron, without protection of any kind, was recommended even by underwriters as a fair fire-resisting material, long after structural engineers had condemned it as unreliable for carrying loads, and especially for resisting shock and vibration. Cast iron columns certainly came through a number of fires in the beginning with very little damage, probably because the fire attack was not very severe. That unprotected rolled shapes, whether in the form of columns, girders, or beams, lose their rigidity at a low temperature, was soon recognized, and they were classed as non-fire-resistive; notwithstanding their greater reliability for structural duty, it is only within recent years that underwriters have looked upon them with favor, even when well protected.

12. Fires and conflagrations of recent times have demonstrated that no unprotected metal structural member is even reasonably safe, and that, after all, the difference between cast iron and rolled steel is very small. This has led to the protection of structural members by means of a covering designed to prevent them from attaining a dangerously high temperature.

13. For a long time, the preservation of the structural frame-work intact seems to have been the whole object of designers. At any rate, this was about all that was accomplished in the Baltimore and prior fires, and even this much was not accomplished at San Francisco.

FIRE-RESISTIVE COVERINGS.

14. A treatise on fire-resistive buildings should touch upon structural details before reaching the subject of fire-resistive coverings. But this is not a treatise, and the current practice of the best engineers is upon such a high plane, so far as structural design goes, that it is only necessary to refer to the many articles descriptive of such designs in the technical periodicals to secure all needed information. The subject of protective coverings is not so well developed because their design, for a long time, was left to those having only a commercial interest in them; but technically supervised furnace tests and the experience of past fires have brought about some improvement, and the way seems open for more in the future; progress in such matters is not rapid, but it is not wholly lacking. See Fig. 171 for standard time-temperature curve used by Underwriters' Laboratories, Bureau of Standards, and others in the furnace tests on column protection, structural materials, fire retardants, etc.

15. The materials used to protect the structural members of a building from fire are all included under the heads of brick, terra cotta, concrete, gypsum, and plaster of various compositions.

16. Of these, **brick** is by long odds the most efficient, when properly made and properly used; but it is also the most expensive.

17. Terra cotta and **concrete** can be made to approximate it in efficiency, but only at approximately the same cost.

18. Gypsum (plaster of paris) is an excellent non-conductor (it has by far the lowest conductivity of any incombustible building material) and expands but little under the application of heat. In more recent years gypsum has been accepted as standard for the protection of columns, girders, and beams, as well as for floor slab construction.

19. Ordinary wall plaster, usually lime, on metal lath offers more or less resistance to fire. As used in the past, it has been incapable of protecting important structural members, a class of service which could not be expected of it. Recent tests by Underwriters' Laboratories on both sanded and fibred gypsum on metal lath has shown very considerable fire resistance. Approximately equal results probably are obtainable with portland cement mortar properly applied to metal lath. The cement gun has distinct usefulness in this field. See page 171.

20. It may be stated here that any incombustible material with a reasonable amount of structural strength may have its sphere of usefulness in fire-resistive construction. A great deal is gained, from the conflagration point of view especially, when an exposed building is entirely incombustible in itself, whether it is fire-resistive or not.

21. Materials subject to the action of fire may fail in one or both of two ways; either through molecular or chemical changes and consequent loss of strength, or through mechanical rupture under stresses induced by expansion.

CHARACTERISTICS OF BRICK.

22. Bricks and terra cotta used for fire-resistive covering should be made of clay, requiring a temperature of at least 2,200 degrees F. to vitrify it. The product will then be secure against destructive molecular or chemical changes in any ordinary fire, provided it has been burned to a point just short of vitrifaction. A porous structure such as is produced by mixing sawdust with the clay makes the product a poorer conductor of heat, and also enables it, within limits, to yield to the compression induced by expansion stresses without mechanical rupture. But the main strength of brick work lies in the fact that it is used in small units, and though it may be laid in the strongest cement mortar, the numerous joints make it possible for each brick to yield a little to expansion stresses, without destroying the brick work itself. Very hard, dense bricks may suffer some by superficial spalling, but it requires many applications of fire seriously to diminish their value as a protective covering from this cause. Bricks, being of homogeneous texture for considerable thickness, may attain a high temperature on the exposed face and remain relatively cool on the opposite face, without having, at any point, a destructively high rate of change of temperature, with its consequent severe expansion stresses.

CHARACTERISTICS OF TERRA COTTA.

23. The cellular construction of terra cotta, and the large size of units ordinarily employed, make it peculiarly liable to destruction by expansion stresses and this has been its chief weakness in actual fires. The exposed webs, being very thin, quickly reach a high temperature; where the exposed webs join the inner webs, there is a rapid rate of change of temperature, accompanied by severe expansion stresses, and the thin webs, not having the mechanical strength to resist them, break off. This action has resulted in completely stripping the covering from columns, and in the total failure of terra cotta floor arches. The cellular construction of terra cotta has often been urged as an advantage, on the theory that dead air spaces were thereby created, with high insulating value. But air spaces, to be of value in fire-resistive coverings, must be perfectly dead, and enclosed in walls of such strength as to insure them against rupture. To make the large cells of hollow terra cotta blocks perfectly dead requires a perfection of manufacture and setting that is entirely unattainable in practice, and to render their walls secure against rupture from expansion stresses, the web of the tiles would have to be from one inch to two and one half inches thick, with all interior angles rounded to a radius of at least two inches. If hollow tiles were made in this way, they would be just as efficient as solid bricks made from the same clay, but they would also be just as heavy and just as expensive.

CHARACTERISTICS OF CONCRETE.

24. Concrete owes its strength to the hydration of the cement, which, in setting, takes up a certain amount of water of crystallization. This water is essential to its strength. At temperatures above 600 degrees F., this water begins to be driven off, and the cement loses strength. When dehydration is complete, the strength of the cement, or concrete, is practically destroyed. The process of dehydration is slow, however, and the dehydrated material is a poor conductor of heat; it generally remains in place for some time, thus retarding the process of dehydration in the interior of the mass. Concrete generally spalls more or less under expansion stresses, but not to a fatal degree. Concrete made of cinders or clinkers does not usually spall, and sometimes it seems not to be weakened, in a fire. There is no question that concrete, properly made and used, is an efficient fire-resistive material, within the practical meaning of that term.

CEMENT GUN.

25. The Cement Gun employs compressed air to shoot a mixture of sand, cement, and water (added at the nozzle) against steel, concrete, wood, or other material. Where partitions or walls are erected, a backing of building paper is used to prevent the spray being dispelled into space. The resultant deposit, called "Gunite" by the manufacturer of the Cement Gun, adheres closely, is exceedingly dense, has reasonable fire-resisting ability, and as a wall or partition, because of the reinforcing used, it has good stability and resistance to heavy impact. Underwriters' Laboratories, after extensive tests, has issued approval covering exterior and interior 12″ hollow non-bearing walls (two 2″ slabs with 8″ air space between) and exterior and interior 2″ solid non-bearing partitions. For repairing concrete damaged by fire or otherwise, the Cement Gun should be of great value.

DETAILS OF APPLICATION OF FIRE-RESISTIVE COVERINGS TO STEEL FRAMES

26. In the following paragraphs are set forth the essentials of protecting different structural members against fire.

COLUMNS.

27. The members of a steel frame requiring protection are the columns, girders, and floor beams. Of these the columns are the most important yet their protection is usually the poorest of all. A thoroughly satisfactory method of fireproofing a column is to cover it with four inches of brick work, and to fill the entire space inside with Portland cement concrete. Results almost as good will be obtained by making the covering of an equal thickness of concrete instead of brick work, in which case the covering and filling would be one homogeneous mass. The failure of a column is such a vital matter that nothing less than the best should be accepted as a fire-resistive covering, and building laws ought to require it. If columns were protected as above described, the protective masonry would stiffen them so that no allowance would be required for flexure in designating them. Moreover, they might very well be designed for higher working stresses, if protected in this way. In a fire, a column that stays cool, under working stresses as high as 20,000 pounds per sq. in., is much to be preferred to one with working stresses half as high, but not adequately protected from heat. Even if working stresses are not increased, the extra cost of the kind of column protection herein described as compared with that ordinarily used would not amount to more than three cents per sq. ft. of floor surface of the average building, so it is not by any means prohibitive. With the suggested increase in working stresses, the saving in steel would fully cover the extra cost of the protection.

28. Until recently the most common type of column protection was hollow tiles simply laid up around the column, with or without metal bands to tie them together. The thickness of the webs was just sufficient to enable the material to be handled in manufacture, and to stand up in the kilns, where the heat is gradually and uniformily applied and each individual piece is relatively free to expand and contract as a whole. Experience in the great fires of the past twenty years abundantly proves the inadequacy of this type of covering. One notable recent advance is the very usual practice of filling all the space between the steel and the outer covering with concrete. Besides the ordinary hollow tile covering, metal lath and plaster have been used; but this is not an adequate protection for so important a member as a column. Brick and concrete coverings have been frequently used,—and where they have been properly applied no instance of failure in an actual fire is known. The other forms have failed, frequently and disastrously, with buckling of columns and consequent collapse of floors above. See Fig. 25, page 184.

GIRDERS.

29. Girders come next to columns as important members of steel frames. They generally project below the floors and have rather severe exposure in a fire. It is customary to cover their lower flanges with wire lath and plaster, with shoes of hollow tiles, or with concrete or gypsum. The sides are protected with the same materials. The lath and plaster covering is always inadequate; the other types are almost always made too flimsy, in an attempt to save weight. The lower flanges should be protected with from two and one half to four inches of solid terra cotta, concrete, or gypsum. If the flanges are wide, some form of metal mesh should be imbedded in or should surround the protective covering, and be anchored on top of the lower flange into the side protection; the object of this being to prevent the covering from falling off, in case it is cracked by the heat. The webs of girders should be protected quite as heavily as the flanges, but here hollow tiles, with webs not less than one and one half inches thick, and well rounded interior angles, will be adequate, and will serve to build the side covering out flush with the covering of the lower flange, without excessive weight. The side covering should extend entirely to the top of the girders and the top flange should be covered with at least two inches of good concrete, or of gypsum, or with bricks laid flat.

30. In general where concrete or gypsum is used for the protection of steel members, it should be expected that from one half to three fourths inch of the material will be destroyed by dehydration in the first fire. Adequately to repair the covering the damaged material should be completely removed, then the member should be wrapped with expanded metal or wire lath, well secured with steel staples or expansion bolts. The covering should then be restored to its original profile with cement or gypsum, plaster, applied in one coat. In the application of a cement coating there is a distinct sphere of usefulness for the cement gun. In the event of a second fire, the metal mesh would probably remain in place, and the dehydrated material could be knocked off and then replaced, as before. This applies to column coverings as well as girder coverings.

FLOOR BEAMS AND ARCHES.

31. The floor beams of a steel frame should be protected with solid terra cotta skewbacks, at least one and one half to two inches thick, or with a somewhat greater thickness of solid concrete or gypsum; if terra cotta is used, the skewbacks should be solid, with only small holes in them to permit of proper burning, or else they should be of the side construction type, with webs at least two inches thick, and well rounded interior angles. End construction skewbacks should not be permitted, as the object is to solidly enclose the lower flange and the web of the beam in homogeneous fire-resistive material.

32. For carrying the floors from beam to beam, nothing better, from a fire-resisting and load-carrying point of view, has ever been devised than the segmental brick arch. If combined with solid protecting skewbacks, this form of floor could not be improved upon, except on the score of appearances where a flat ceiling is desired. A four-inch arch, with a reasonable rise, will carry the heaviest loads over any span found in any building, with perfect safety; and the same qualities that make solid bricks the best material for the arches of furnaces and the domes of kilns make them the best material for floor arches, if weight and a curved ceiling are not objectionable.

33. If weight must be saved, and a flat ceiling is imperative, then a flat hollow tile arch, on the end construction plan, but with the solid skewbacks above described, is the best form; but the webs should be at least one inch thick, and in important buildings, one and one half inches should be the minimum.

34. Reinforced concrete slabs may be used to span the space from beam to beam; when combined with adequate protection for the webs and lower flanges of the beams, this form is as good as the heavy terra cotta above described, better than ordinary terra cotta flat arches, and almost as good as brick arches. Gypsum floor slabs and arches can be used, and made fully equivalent to ordinary flat bottom tile arches; but either of these forms is almost certain to be so damaged in a fire of considerable intensity as to require complete renewal. Suspended metal lath under a flat hollow tile arch of the ordinary kind, and plastering on the lath, as was done at Baltimore, is not an adequate method of repairing arches which have lost their soffit webs in a fire; and especially when the arches are of the side construction type.

REINFORCED CONCRETE BUILDINGS.

35. If the framework of a building is wholly or partly of reinforced concrete, the members demanding attention are still the columns, girders, and floor beams.

COLUMNS.

36. A reinforced concrete column has a reinforcement imbedded within it, consisting of a group of light longitudinal steel members disposed in a regular manner, within, but near the periphery, and usually connected with each other by horizontal or spiral metal bands. Considered from the point of view of structural duty alone, there should be enough concrete outside of the reinforcements thoroughly to protect it from corrosion, and no more. The reinforcement should be so disposed as to reinforce the column against buckling in any direction, and the steel and concrete together should be capable of carrying the load with unit stresses, which will not call for deformations beyond safe limits for the concrete. This is a complicated and intricate subject, involving intimate knowledge of the materials, and of applied mechanics, and then a ripe and mature judgment on the part of the designer. See Fig. 25, page 184.

37. The ideal way to treat it as a fire-resistive member is to make the structural part as a unit, then enclose it with drums or slabs of reinforced concrete, made of metal lathing and a concrete designed especially to resist fire. For this purpose, an aggregate of broken bricks, broken to pass a three fourths inch ring, or of a clean, thoroughly burned clinker, is the best. The fire-resistive covering should be at least two and one half inches thick, and should be applied to the column after the latter has set. If this method is not adopted, then the only other way is to include in the column itself enough surplus material outside of the reinforcement to allow for probable fire damage, without affecting the structural value of the column. While dehydration does not ordinarily take place to a greater depth than one inch, cracks may penetrate much farther, and if the outer part of the column itself is to furnish the first line of defense, the surplus material should be at least four inches thick.

38. It is very bad practice, as a general proposition, to use the same material for structural duty and also for resisting fire. The fire alone will give it stresses enough to resist, without having them super-added to existing structural stress. If the reinforced concrete column is made larger, with a view to standing a certain loss of its own material without having its undamaged part reduced below safe limits from a structural point of view, the material added for fire-resisting will participate in the load-carrying functions of the column, in spite of all that can be done; to that extent it will be less able to resist fire. The plan of a separate fire-resistive covering is so much better that it should be required in all important cases. Even if fire cracks should extend entirely through this separate covering, and even if the entire covering reached a temperature sufficient to soften steel, the column within could not suffer any serious damage in any fire likely to occur. For this reason a thickness of two and one half inches is considered sufficient for the separate fire-resistive covering of a reinforced concrete column, while four inches is considered necessary, if the fire-resisting is incorporated with the column itself.

GIRDERS AND BEAMS.

39. Reinforced concrete girders and beams offer a large saving as compared with steel girders and beams protected against fire. This is the only valid reason for their use as a general proposition, but it is sufficient. In the present state of the art, it is necessary to incorporate their fire-resistive covering with the members themselves, or else sacrifice the economy due to their use.

REINFORCEMENT OF BEAMS.

40. Concrete beams should be reinforced with horizontal members to take the tensile stresses due to flexure; and with web members to take up the tensile stresses due to shear. The theory of the reinforced concrete beam is very complete at the present time, and no detailed discussion such as appeared in earlier editions of this work is necessary. However, one or two points should be emphasized.

a—The stresses in horizontal members consist of the accumulated horizontal components of web stresses. The bond of the concrete should not be depended upon to connect the web members to the horizontal members but this should be done by connecting web members securely to horizontal members, steel to steel. See Fig. 24.

b—Web members should be spaced so as to take up the tensile stresses due to shear, where they originate.

c—Web members should always be inclined at an angle of not more than 45° to the horizontal for uniform loading; if serious concentrated loads are to be expected, the angle should be less than 45° to prevent the possibility of compressive stresses in web members near the points of concentration.

FLOOR SLABS.

41. The floor slabs of a reinforced concrete building may be of solid reinforced concrete, or they may consist of a series of parallel reinforced concrete joists, cast in between rows of hollow tile spacers. In either case, they should be reinforced and protected in the same manner as the beams, for they are nothing but beams applied to a special purpose. They are of less importance than beams and girders, and may receive the minimum of protection, but it should not consist of less than one inch of surplus concrete, even in

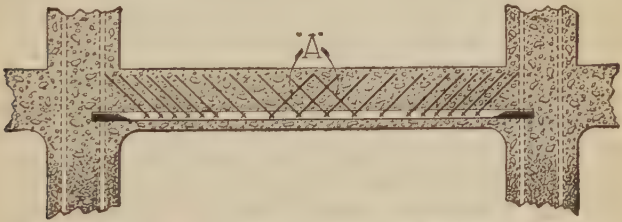


FIG. 24. PROPER FORM OF REINFORCED CONCRETE GIRDER OR BEAM.

Full Lines Denote Reinforcing Members for Girder; Dotted Lines Reinfocement for Columns—"A" "A" Shows Reverse Reinforcement—"x" Rods Securely Fastened to Bar.

extreme cases; as a general rule, one and one half inches should be the minimum protection for the reinforcing members. A reinforced concrete slab—whether of solid concrete, or of concrete joists and hollow tile spacers—is much more secure under the impact of falling objects than a hollow tile slab between steel beams. Where a solid reinforced concrete slab is used with a framework of the same material, a suspended ceiling below the slab is an excellent addition, just as in the case of a similar slab supported by steel beams.

MUSHROOM TYPE OF CONSTRUCTION.

42. This is a form of reinforced concrete that has been widely and successfully used. It consists of a continuous slab of uniform thickness, except near and around the columns, resting on columns with expanded (or mushroom) heads; often, the slab itself is thicker for some distance from the columns. This type obviates girders projecting below the ceilings, probably reduces the necessary height of stories in many cases, and is claimed to be more economical in first cost. The stresses in its various parts are bound to be more or less indeterminate,—but that is probably true to a greater extent than is generally believed of all sorts of structures,—even the steel-frame type. In any case, enough empirical data have been accumulated from deflection tests of actual structures under different conditions of loading, to permit of any type of structure in common use being designed with an adequate factor of safety, no matter to what extent it may defy purely theoretical analysis. The author would remark, in passing, that the desire of structural engineers to make the stresses in structures theoretically determinate, has resulted in the use of much material that might have been saved. Buildings of all kinds, on reasonably good foundations, would be much lighter, just as secure under load, more rigid under vibration, and materially less expensive, if the principle of continuity of members had been more generally accepted, in spite of the uncertainty as to actual stresses. Reinforced concrete has forced continuity of structure upon us in spite of ourselves, and it is the secret of the success of many buildings, which, when tested by the ordinary methods of analysis, seem dangerously inadequate, but are evidently not so, as a matter of fact.

REPAIRS AFTER DAMAGE BY FIRE.

43. This is a subject not often adequately considered. The record of loss adjustments after every serious fire is sufficient to prove its importance, especially when considered in connection with the kind of repairs often made. In the case of steel frame structures all that is necessary is to realize the importance of the question. The data are available to enable the designer to handle the question properly.

44. In the case of reinforced concrete columns, this consideration greatly emphasizes the importance of a covering not integral with the necessary structural part of the column. See par. 37. In the case of girders, if the reinforcing steel has not taken a permanent deflection due to the fire,—**and if the web members are fastened adequately and directly to the main members**, damaged material can be knocked off and new material applied, so as to restore the damaged member to its former usefulness. Here the cement gun would seem to have a sphere peculiarly its own. Where concrete, added for fire protection, is integral with that required for structural duty, and where dehydration, spalling, and cracking have developed to a serious extent, it must always be problematical to what extent adequate repairs can be made,—and to what extent reconstruction may be necessary. In the latter case, the removal of the fatally damaged members introduces an element of cost that may make a fire loss " more than total."

PARTITIONS.

45. The materials available for partitions are bricks, concrete, heavy hollow tiles, gypsum, light hollow tiles, and plaster on metal lathing. Combustible materials are not considered in this connection. It is not possible to arrange partitions in the order of their merit, based on the materials used in their construction, because so much depends also on the manner in which they are used. The type to be adopted, and the degree of resistance to be attained, depend upon the duty expected of the partition in each case. If a part of the duty of the partition is to accomplish the general subdivision of a large floor area for fire protection purposes, then the partition should develop a resistance equal to that of the main structure of which it is a part; if its duty is merely to subdivide space for convenience of daily use, it should be strong enough to stop one moderate fire; even if the damage suffered requires complete renewal of the partition, this is a small matter. If such partitions confine a fire starting within, to the place of its origin, they have done their full duty; to make them much stronger than this is financially unjustifiable.

46. It should not be forgotten that in actual fires, expansion stresses have wrecked many partitions whose resistance was otherwise sufficient. Wooden studs extending from floor to ceiling and wooden lintels incorporated in hollow tile partitions, have often been a source of fatal weakness. The ability to resist tensile stresses due to expansion is a strong point in favor of reinforced concrete, as a fire stop. There is no reason why such reinforcement may not be provided, where necessary, for brick walls as well. It is nearly always possible to make some allowance for expansion, in the design; partitions carried on the structure, story by story, —or several stories at a time,—need not be wedged tightly in between floor and ceiling; light metal guides on either side at the ceiling can be used to enclose a small space left for expansion, and will also strengthen the partition against being overthrown.

FIRE-RESISTIVE PROPERTIES OF THE BUILDING AS A WHOLE.

47. If a building is constructed and its members protected in accordance with the best standard indicated in what precedes, it will stand the combustion of its contents without very serious damage to itself, except in extreme cases where the contents are capable of producing a very hot and very prolonged fire. But it might still be gutted by a fire originating within, unless other matters also are carefully considered.

48. The first of these is adequate subdivision of the interior space by partitions capable of holding a serious fire, together with protection of stairways, elevators, and floor openings, so as to prevent the communication of fire throughout the interior. See Chap. 13. Sprinklers and other forms of active defense come in here, along with the more passive resistances.

49. The second important matter is the protection of the building from exposure fires,—which, if adequately done, will equally prevent the building from passing a fire originating within to its neighbors, through unprotected openings,—and will, of course, make the building highly efficient as a conflagration stop. See Chap. 15.

GENERAL CONSIDERATIONS.

50. The standards of fire-resistive construction implied in this chapter are high; had they been realized in the so-called fire proof buildings involved in the great conflagrations of the last twenty years,—along with reasonable protection against exposure fires,—these buildings would have given a much better account of themselves, and would have justified the greater first cost of the higher standards,—at least, from the standpoint of the business community as a whole, and from that of the minimum drain upon the accumulated insurance capital of the country. Unfortunately the interests of owners and the community in this matter have not been brought into entire accord; and there are limits set by the amount and cost of available investment capital which often make it impossible to attain the standard that is most desirable in a particular case, even when this standard is, in itself, not the highest.

51. Much is gained, however, whenever incombustible material can be substituted for combustible, in either structure or finish, whether the former is capable of much or little resistance to fire; it at least can not add fuel to the flames. A building, capable of withstanding in itself only a moderate fire test, if well protected from exposure fires, may be a better conflagration stop than one which is, in itself, a very excellent and resistant furnace,—in which its contents may be burned without much damage to the furnace,—unless the latter is also so designed and protected that its contents are not likely to be ignited; the combustion of the contents without serious damage to the structure is not the real object in view,—although the assumption that it is, has been, unconsciously, the basis of many attempts at the design of fire-resistive buildings.

52. When every building is incombustible in itself, fire-resisting to a reasonable degree, well protected against exposure fires, and provided with the means of a good active defense, the highest standard of fire-resistive construction will rarely be necessary.

53. In the meantime, it should be required in all cases where great values are involved in conjunction with inherent inflammability and exposure to conflagration,—and especially where the presence of many people is of daily occurrence.

54. A more moderate standard should be required for such buildings as hotels, apartment houses, and office buildings,—but it should not be lowered too much as compared with the best.

55. A third standard, based primarily on incombustibility combined with some protection against exposure, and with such means of prevention as sprinklers, etc., should be encouraged in every possible way, in cases where the only possible choice lies between a combustible building and the cheapest possible type of incombustible construction. Probably this policy, successfully applied, will do more to prevent conflagrations and diminish fire losses than any other available at this time. With increasing scarcity and cost of lumber, and with increased skill in the use of cement and its products, the time seems opportune to banish both combustible and unprotected buildings from all areas that are either actually or potentially congested. The cost of combustible construction has increased, but its rate of depreciation and cost of upkeep have not diminished. Probably the time is here when the superiority of fire-resistive construction in these respects will make it the more economical investment, regardless of the risk of fire loss and the insurance rates, matters in which the advantage has always been with the fire-resistive type.

FIRE TESTS OF BUILDING COLUMNS

56. The report on the notable fire tests of building columns conducted at Underwriters' Laboratories in 1917 and 1918 by the Associated Factory Mutual Fire Insurance Companies, the National Board of Fire Underwriters, and the United States Bureau of Standards, warrants careful study. It is impossible to present the results in very brief form, but the following high points of the report have been extracted as of particular moment. See table on page 185.

a—106 fire tests were made under load, and in fifteen cases hose streams were applied to columns while at high temperature.

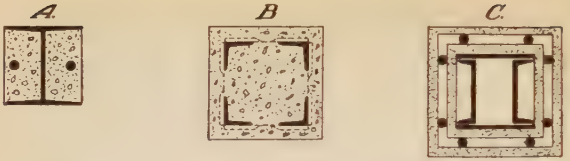
b—A large variety of columns, unprotected, partly protected, and effectively protected were tested up to point of failure or for eight hours as a maximum. See Fig. 25 for typical constructions tested, and page 733 for standard time-temperature curve.

c—The useful fire-resistance period for any type of protection has been placed at two thirds of the average time to failure of the group tested, provided no single test was of shorter duration than the designated period.

d—An astonishing difference in fire-resistive value of different aggregates for concrete was observed. Limestone or limestone gravel gave best results, trap rock, granite, sand stone, or hard coal cinder, ranked next, and siliceous gravel was least effective. This accounts for such remarkable ranges as in line 7. The best figure in each case is for limestone aggregate.

e—With hollow tile, a great difference in fire-resistance is secured by filling open spaces between the column and tile with concrete. Medium hard, semi-fire clay tile is best. Unfilled tile protection gives very indifferent results.

57. Taking into account all factors, it would seem as if the relative grading of the column covering materials tested were in the following order: Concrete; brick; gypsum; tile; metal lath and plaster; confirming quite definitely the general opinion of engineers, except that ordinarily brick has been placed ahead of concrete.

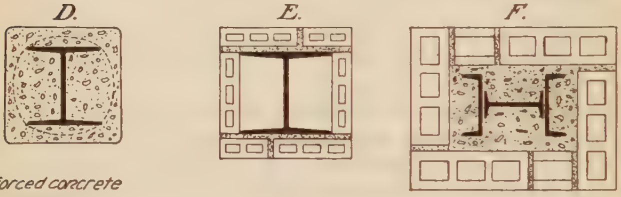


Solid section

Hollow section

PARTLY PROTECTED COLUMNS

TWO COVERINGS METAL LATH & PLASTER PROTECTION



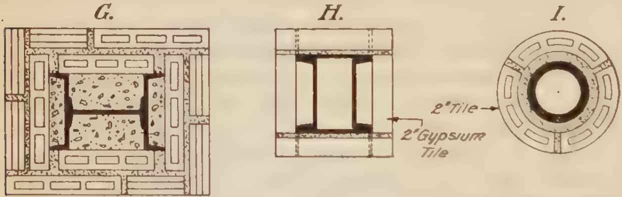
Reinforced concrete protection

Unfilled

Concrete fill on all sides

CONCRETE PROTECTION

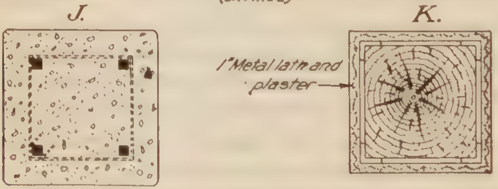
HOLLOW CLAY TILE PROTECTIONS



DOUBLE CLAY TILE PROTECTION

GYPSUM TILE PROTECTION (Unfilled)

CAST IRON COLUMN PROTECTED BY CLAY TILE



VERTICALLY REINFORCED CONCRETE

TIMBER COLUMN PROTECTED WITH GYPSUM BOARD & METAL LATH & PLASTER

FIG. 25. PROTECTION OF COLUMNS, INCLUDING THE PRINCIPAL DESIGNS TESTED AT UNDERWRITERS' LABORATORIES

USEFUL FIRE RESISTANCE PERIODS OF BUILDING COLUMNS AND COVERINGS

(Tests at Underwriters' Laboratories in 1917 and 1918)

Item No.	Type of Protection	Type of Column Section	Case in Fig. 24	Minimum Area of Solid Material Sq. In.	Useful Fire Resistance Period
		Structural Steel Columns			
1	Unprotected	Any type		8	10 min.
2	Partly Protected	Solid Steel	A	35–60	½ hr.–¾ hr.
3	" "	Hollow Lattice	B	120	2 hr.–3½ hr.
4	Metal Lath and Plaster	Any type (one and two coverings)	C	40–80	¾ hr.–1½ hr.
5	Concrete—2″	Any type—Concrete filled	D	100	1 hr.–4 hr.
6	" —3″	" " " "	D	140	3½ hr.–6 hr.
7	" —4″	" " " "	D	200	2½ hr.–8 hr.
8	Hollow Tile—2″, 3″, 4″	Solid Steel—Unfilled and filled	E-F	80–160	1 hr.–1½ hr.
9	" " —2″, 3″, 4″	Any type " " "	E-F	160	2 hr.–2½ hr.
10	" " —2 layers 2″	Solid Steel	G	240	1 hr.–3 hr.
11	Common Brick—2¼″	Any type—Brick Filling		140	1 hr.
12	" " —3¾″	" " " "		240	5 hr.
13	Gypsum—2″ Solid Block	" " —Gypsum filling	H	130	1½ hr.
14	" —3″ " "	" " " "	H	180	2½ hr.
15	" —4″ " "	" " " "	H	240	3½ hr.
		Round Cast Iron Columns			
16	Unprotected	Minimum Wall thickness 0.60″		12	25 min.
17	" (concrete filled)	" " " "		35	½ hr.
18	Metal Lath & Plaster—1½″	" " " "		60	2 hr.
19	Concrete—2″	" " " "		70	2 hrs.
20	Hollow Tile—2″	" " " "	I	70	2 hr.
		Reinforced Concrete Columns			
21	2″ integral Concr. Protection	Round or Square	J	220	5 hr.–8 hr.
		Timber Columns			
22	Unprotected	Steel plate cap bearing—unprotecter		120	25 min.
23	"	Cast Iron cap and pintle "		120	¾ hr.
24	½″ Gypsum Wall Board	Either cap—protected		140	¾ hr.
25	Metal lath & Plaster 1″	" " "	K	160	1½ hr.

58. It must be noted that the Joliet limestone used as an aggregate for concrete is probably superior to much limestone in other parts of the country, and that the bricks used in the tests were made of surface clay containing an appreciable amount of lime. Bricks made of refractory clay would have given better results. Depending on the clay used and the degree of burning, the resistance of brickwork to fire may vary from a standard that is barely acceptable to the very best attainable.

FIRE-RESISTIVE CONSTRUCTION.

(Extracts from the National Board Building Code.)

59. From the very complete specifications, both for steel frame and for reinforced concrete buildings, contained in the Building Code recommended by the National Board of Fire Underwriters, the following material has been extracted as of general interest.

General Requirements.

60. Space between floor arches and floor finish should be solidly filled with concrete.

61. Floors should be made impervious to water, and arranged to drain to scuppers or interior drain pipes. This is to prevent accumulation of water on any floor, as well as to reduce the danger of leakage through floors. See Fig. 27, page 193.

62. Shafts and public hallways should be enclosed in fire-resistive enclosures, and stairs and landings should be of incombustible material.

63. The maximum of combustible material allowed in the construction of a fire-resistive building is: top or wearing floors and sleepers, the latter imbedded in concrete; interior doors and windows including frames and casings; interior finish backed with fire-resistive material; wooden wainscoating over 3′ high and wooden ceilings are not permitted.

64. Exposed wall openings should be protected. See Chapter 15.

Floor and Roof Construction.

65. The Code provides for brick, concrete, terra cotta, gypsum, and any other form of construction that may be developed.

66. Where steel tie rods are used, they should be encased to a depth of at least 2″ with fire-resistive material.

Protection of Structural Members.

67. The essential points are shown in tabulation on next page.

Miscellaneous Provisions.

68. Defective or damaged materials not to be used.

69. No pipes, wires, cables, or other material shall be encased within or imbedded in the fire-resistive protection of structural members.

70. Permanent partitions, such as those enclosing public halls or separating spaces occupied by different tenants, shall be at least 4″ thick (not including plaster), of brick, terra cotta, concrete, or gypsum block, or not less than 3″ thick, of reinforced concrete or of solid metal lath and cement plaster; or of other approved materials.

71. Openings in public hallway partitions shall be protected by approved fire doors or fire windows. Glass is not permitted in partitions separating tenants; and preferably there should be no openings in such partitions.

Reinforced Concrete Construction.

72. Reinforced concrete is approved for all types of buildings. The concrete shall consist of one part of cement to not more than six parts of aggregate, usually divided two parts sand and four parts stone or gravel to produce maximum density. For greater crushing strength, as for columns, one part cement to four and one half parts aggregate may be desirable. The concrete shall be tested for crushing strength by means of test samples.

73. The fine aggregate shall consist of clean sand, crushed stone, or gravel screenings, passing a ¼″ diameter screen.

74. The course aggregate shall consist of crushed stone or gravel, retained on a ¼″ diameter screen, and passing through a 1¼″ diameter ring, graded in size. Pure quartz, limestone, dolomite, slate, and shale generally give poor results, as they calcine or spall when exposed to high heat. Traprock and conglomerates, consisting essentially of coarse grained sandstone, make good concrete.

75. Round reinforced concrete columns are better adapted to resist fire than square columns.

76. Reinforced concrete walls shall be not less than two thirds

MINIMUM FIRE-RESISTIVE COVERINGS FOR STEEL

(Amounts of covering given in inches)

	Brick	Concrete	Terra Cotta	Gypsum	Notes
STEEL FRAMES:					
Wall Columns	4	3			Also ¼″ cement mortar to protect against corrosion.
Wall Girders	4	3			Also ¼″ cement mortar to protect against corrosion. Outer edges may project within 2″ of surface of covering.
Interior Columns	3	3	3	3	Outer edges may project within 1″ of surface of covering.
Interior Girders and Trusses	2	2	2	2	
Beams and Lintels	1½	1½	1½	1½	
Pipe Columns		1½		1½	To be filled with concrete or gypsum. Brick and terra cotta coverings not forbidden, but not practical.
REINFORCED CONCRETE:					
Wall and Column Footings		4			
Columns and Girders		2			
Walls and Beams		1½			
Floor Slabs		1			

the thickness required for brick walls, with 8″ the minimum. Walls shall be reinforced with steel both horizontally and vertically.

77. Steel reinforcements shall be free from excessive rust, grease, or any coating which would reduce the bond between the steel and the concrete.

78. All reinforcement shall be accurately located and mechanically secure against displacement during placing of concrete.

79. Good workmanship is essential. This includes the following: accurate measuring and thorough mixing of materials; thorough tamping; removal of all foreign materials; prevention of rapid drying or of freezing; substantial and careful construction of forms; ample time for concrete to set before removing forms.

80. Every reinforced concrete building shall be under constant supervision of a reputable and competent inspector.

Authors' Note: The opinions set forth in par. 74 regarding the merit of aggregates does not agree with the results of the Chicago column tests described in pars. 56 to 58. Also the mature judgment of Col. Sewell varies somewhat from both sets of opinions. As regards the fundamentals of good construction all authorities agree.

CHAPTER 12

MILL CONSTRUCTION

(Also known as Slow Burning Construction)

1. Mill construction originated in New England, and was developed to meet the needs of the textile industry. Decades ago it was used almost exclusively in this industry; later it was adopted in scores of other types of manufacturing plants. Until the last decade and a half, during which fire resistive construction has rapidly been developed, practically all of the finest industrial plants were of mill construction.

ADVANTAGES OF MILL CONSTRUCTION.

2. The fundamental advantages of slow-burning or mill construction over quick-burning or joisted construction are as follows:

a—Tight floors 4″ or thicker, free from unprotected vertical openings, and difficult for fire to burn through.

b—Heavy posts and girders with smooth surfaces and few corners, making difficult their ignition and giving ability to resist fire for a considerable time.

c—Freedom from concealed spaces.

d—Smooth underside of floors, together with judgment exercised in the spacing of girders, making for economical sprinkler installation.

e—Good carrying power of floors.

f—Ability readily to fasten machinery in place and to attach line and countershafting, and to move it as required.

g—Ability to get very considerable waterproofing of floors through use of waterproof paper, properly flashed, and placed between the plank under floor and the tongued and grooved finish floor; this in conjunction with scuppers carried through outside walls.

3. Until more recent years, during which the cost of timber has materially increased, the cost of mill constructed buildings was appreciably less than that of fire resistive ones. Under present conditions there is generally little to choose between these two types of construction so far as cost is concerned, and consequently fire resistive buildings are commonly being erected even in the industries where mill buildings have long reigned supreme.

DISADVANTAGES OF MILL CONSTRUCTION.

4. Leaving out of question the relative costs, the disadvantages of mill construction as against fire resistive construction are primarily as follows:

a—While recognizing the fine record of mill construction buildings under sprinkler protection, it is from a fire standpoint fundamentally desirable to avoid, if possible, any form of combustible construction.

b—Modern operations frequently make advisable wider column spacing than is possible with mill construction, especially where floor loads are heavy.

c—More vibration is likely to be incurred in a building having timber floors rather than concrete ones.

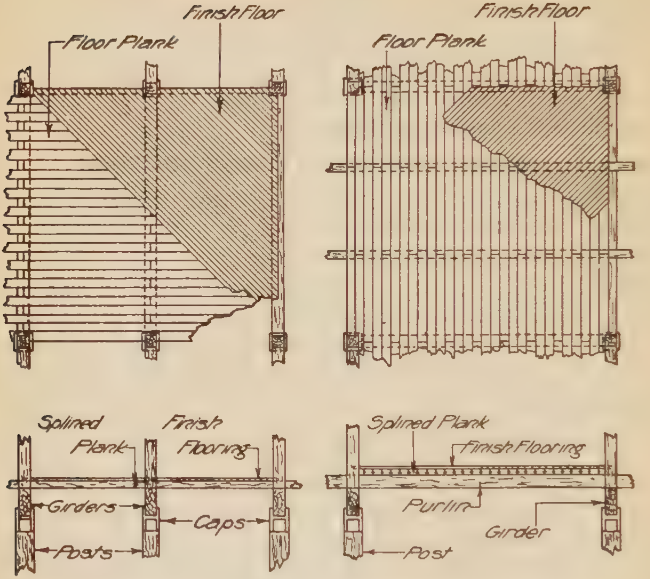
d—Dry rot occasionally takes place in posts, girders, or floor planks of slow-burning buildings, especially where the laminated type of floor is used. See below. The dry rot danger has increased with the shortage of long leaf pine and the use of other woods in its place.

e—Mill construction buildings are seldom erected over four stories in height. The highest group of such buildings in the country probably is the older nine-story-and-basement one of Sears, Roebuck & Company in Chicago. There the columns in several of the lower floors are of metal on account of the great weight that has to be carried.

DETAILS OF CONSTRUCTION.

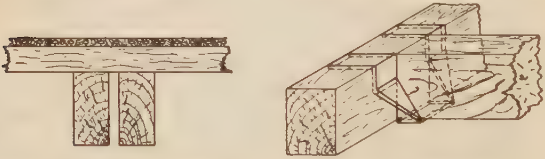
5. Figs. 26 and 27 show certain features of construction, both approved and unapproved.

6. True mill construction, with rows of columns up to 20



True Mill Construction

Compromise Mill Construction



Double Stick Girder with Air Space Not Approved

Metal Stirrup Not Approved

Fig. 26. Mill Construction—Floors.

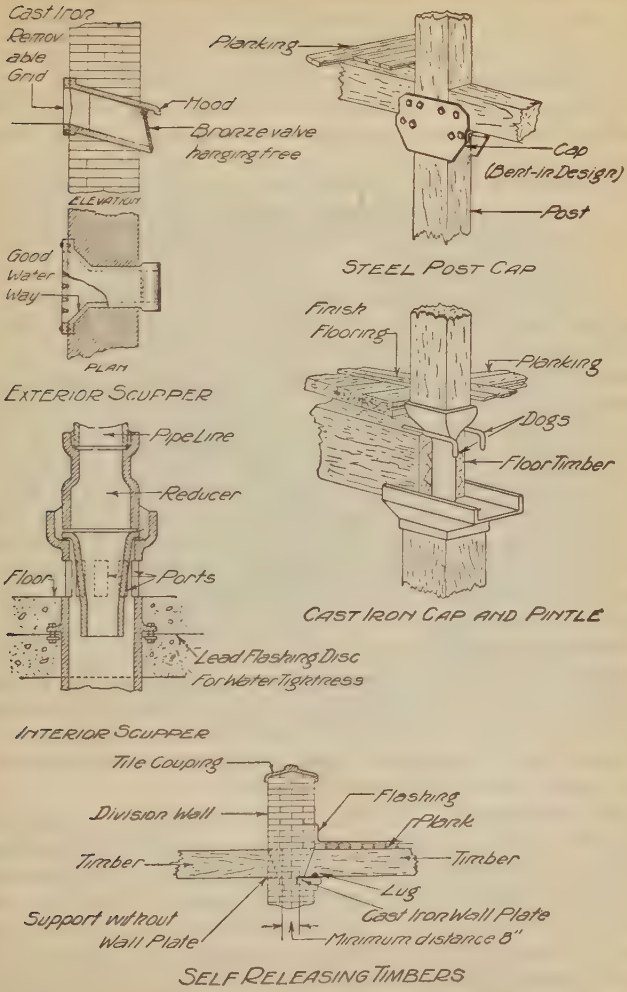


FIG. 27. MILL CONSTRUCTION DETAILS.

ft. on centers, with girders running the length of the building, and with floor planks spanning the girders (spans ordinarily 8 ft. to 10 ft.), is the simplest and best form.

7. Compromise mill construction has been devised to secure greater column spacing, and is made possible by the introduction of purlins, resting on girders, and in turn carrying the floor planks.

8. Laminated floors, where planks on edge, up to 10 or 12 inches wide, are used, make wide spans and heavy floor loads possible. Danger of dry rot is greater with such construction than with planks laid flat.

9. Steel frames carrying plank floors, or steel columns carrying wooden girders and floors, are occasionally found. Unless the steel columns are protected against fire, such construction is exceedingly susceptible to collapse, assuming no sprinklers or a sprinkler failure. A notable instance was the Atlantic Building in Chicago, burned out by exceedingly severe exposure in what is commonly called the Burlington Building Fire, of March 15, 1922. Construction was brick, steel posts and girders unprotected, and plank floors. In spite of wired glass windows and automatic sprinklers, fire swept into the structure on virtually all stories simultaneously, and building is reported to have collapsed within about twenty minutes.

10. Double stick girders with an air space between are objectionable because fire can get into the space and be impossible to reach with sprinklers and difficult to reach with hose streams. Fig. 28 illustrates the effect of fire on this form of construction. Where the loads require two or more timbers they should be bolted or spiked together.

11. Ordinary steel or wrought **iron stirrups** have less fire-resisting power than construction in which the girders or purlins rest on other timbers, chiefly because such stirrups readily soften under heat, and also because of defective design and workmanship. To use Underwriters' Laboratories' approved malleable iron joist and wall hangers, however, is good practice, and economical in securing maximum clear story heights for a given building height. Approved malleable iron and steel post caps are superior to cast iron, and are being used generally today in mill buildings. Furnace tests of reinforced concrete post caps have shown them to possess excellent fire resistance and load carrying capacity.

12. Some of the above listed substandard construction features, together with other deviations from standard practice have been responsible for failures in fires of buildings which improperly have been termed mill construction. A building that does not conform in all essentials to the construction features listed below is not a mill building in the correct sense of the word.

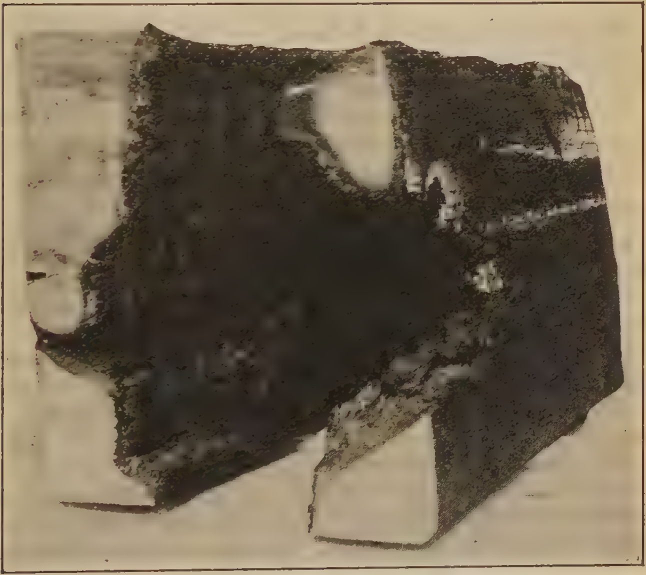


FIG. 28. EFFECT OF FIRE ON DOUBLE STICK BEAM WITH AIR SPACE.

MILL CONSTRUCTION SPECIFICATIONS.

(Extracts from National Board Rules and National Board Building Code.)

Outside Bearing Walls.

13. Brick, laid up with Portland cement mortar, or reinforced concrete. For ordinary story heights not less than 12″ thick for the upper two stories of a building not over five stories high, not less than 12″ thick for the upper story in a building over five stories high, and thickness to increase 4″ for each two stories or fraction thereof.

14. 12″ walls over 60 ft. in length and 16″ walls over 100 ft. in length shall be 4″ thicker throughout unless properly braced by cross walls, pilasters, or buttresses.

15. The thickness of non-bearing walls may be 4″ less than of bearing walls, except that thickness shall be not less than 12″ except in case of reinforced concrete construction.

Protection Against Exposure.

16. Where there is external exposure, outside walls should be parapetted at least 3 ft.

17. Openings in outside walls shall have smallest practical area and be protected against exposure. See Chapter 15.

18. All windows and other openings in side walls of buildings, for a distance of at least 10 ft. each side of a fire wall, shall be protected with approved fire windows, shutters, or doors.

19. Where main cut off sections adjoin so as to form an angle, all windows or other openings in the side walls, for a distance not less than 30 ft. from the angle, shall be protected in an approved manner. Where there are no openings in one wall, the other need not be protected. Where minor sections, such as boiler or engine houses adjoin, the above rule need apply to main sections of building only.

Fire Walls.

20. Brick, laid in Portland cement motar, or reinforced concrete. Non-bearing walls shall be not less than 16″ thick in upper four stories or upper 50 ft., increasing 4″ for each two stories or fraction thereof below. No such two story increment shall exceed 30 ft. in height.

21. Parapets to be not less than 12″ thick if of brick or 8″ if of reinforced concrete, cut off projecting cornices or overhanging roof, extend above roof at least 3 ft. and be coped with durable material. See Fig. 23. page 159.

22. No timbers let in from opposite sides of wall to have less than 8″ of solid masonry separation.

23. All openings in walls to be protected with approved fire doors on each side of wall.

Heights and Areas.

24. Average height above ground level not to exceed 5 stories or 65 ft. if unsprinklered. or 6 stories or 75 ft. if sprinklered.

25. Areas are limited as follows:

Fronting on	Without Sprinklers	With Sprinklers
1 street	6,500 sq. ft.	13,000 sq. ft.
2 streets	8,000 sq. ft.	16,000 sq. ft.
3 streets	10,000 sq. ft.	20,000 sq. ft.

Note: Area of floors in buildings three stories or less in height, sprinklered and with non-hazardous occupancy, may be increased.

Floor Timbers and Posts.

26. Planking to be not less than 3″ (2-3/4″ dressed) splined or tongued and grooved, covered with 1″ (7/8″ dressed) flooring laid cross-wise or diagonally. Two layers of flooring gives better conditions. Two thicknesses of waterproofed paper or saturated felt, flashed at least 3″ at posts and walls, are recommended for waterproofing.

27. Floor timbers shall be not less than 6″ and posts not less than 8″ in either dimension. Timbers shall be self-releasing and at walls rest on wall plates, or in wall boxes.

28. The rules contain specific provisions for allowing for expansion of floors in event of being wet, and provide in detail for kinds of wood used and its condition and preservation.

Roof.

29. Planking to be not less than 2½″ (2¼″ dressed) splined or tongued and grooved, covered with Class A roofing. See Chapter 14.

30. Roof timbers to be single stick, self-releasing, and not less than 6″ in either dimension.

Vertical Openings.

31. Vertical openings to be as few in number as possible, and to be enclosed in brick or reinforced concrete shafts, with generally minimum thickness of 12″ and 8″ respectively, to be parapetted 3 ft. above roof if extending to that point, and to have openings protected with fire doors.

32. In buildings not more than 3 stories in height and sprinklered the enclosure of stairways may consist of steel or wooden stud filled with incombustible material like plaster blocks, or terra cotta, and covered with ¾″ thick Portland cement plaster on heavy metal lath, and shall not be less than 5½″ over all. See also Chapters 13 and 15.

Scuppers.

33. Scuppers are most efficient under the following conditions:

a—When floors are water-tight.

b—When stair and elevator door sills are raised, except there be good drainage from the bottom of the shafts.

c—When pipes passing through floors either fit tightly or run through sleeves which fit tightly and project upwards about 3 ins.

d—When floors are sloped approximately 1 in. in 20 ft. towards scuppers, and they are designed not to have the outlet obstructed by storage.

e—When goods subject to water damage are skidded at least 6 ins. above the floor.

34. A well known type of exterior wall scupper is shown in Fig. 27, as well as an interior scupper. The outside wall scupper is made with a weather-tight flapper at the outer end and protective bars at the inside wall line to keep the scupper from being clogged.

35. Scuppers shall be designed to give a discharge of 100 gallons per minute for 3″ head of water, and scuppers shall be sufficient in number to give a capacity of 100 gallons per minute for each 500 sq. ft. of floor area.

REFERENCES.

36. For full details of construction of mill buildings, readers are referred to the following:

Building Code of the National Board of Fire Underwriters, New York City.

Publications and Charts of the Associated Factory Mutual Fire Insurance Companies, Boston, Mass.

Publications and Charts of the Factory Insurance Association, Hartford, Conn.

CHAPTER 13

STRUCTURAL IMPROVEMENTS FOR EXISTING BUILDINGS

1 Much can be done in a large percentage of existing buildings to reduce the rapidity and extent of fire spread, the amount of combustible construction and finish, and the susceptibility to exposure fires and thereby put forward life and property safety The essential structural improvements which can be made in existing buildings are included in the following:

a—**Vertical Openings,** such as elevator shafts, stair shafts, belt holes, pipe holes or shafts, dumb waiter shafts, floor wells, light wells, and skylights should be closed up or protected.

b—**Concealed Spaces** formed by sheathing on walls, ceilings, and partitions should be eliminated, and horizontal or vertical flues created by sheathing which cannot be removed should be stopped off.

c—**Combustible Construction** should be reduced to a minimum, as by the removal of combustible finish, partitions, shelves, and cupboards.

d—**Wooden Cornices,** overhanging wooden roofs, not vitally necessary combustible roof structures, adjoining sheds, and wooden connecting bridges or passageways should be removed.

e—**Whitewash** or cold water paint should be used liberally to encourage cleanliness and mildly to retard fire.

f—**Skylights** should preferably be wired glass in metal frames (except over fire-resistive stair or elevator shafts where thin glass is required), or if thin glass is used should have screen protection above and below the one for protection against brands, and the other against broken glass falling on persons below.

g—**Broken Windows,** open scuttles, unscreened slatted ventilators, or other unprotected openings may admit brands or sparks, and should be repaired, kept closed, or screened as the conditions warrant.

2. For discussion of improvements in or provision of:
Fire Walls—see Chapter 10 and 12.
Fire Doors and Wired Glass Windows—see Chapter 15.
Roofing—see Chapter 14.

3. It is most desirable that every building, and especially older combustible, unsprinklered ones, be critically examined with a view to achieving results of the kind outlined above, and that definite policies be established not to introduce combustible construction, unprotected floor holes, or other defects in the future. One important plant, by adopting the policy of never putting in any more combustible construction and of occasionally tearing out some wooden portions, gradually and without serious expenditure in any one year transformed itself from an average plant from a fire protection standpoint into a very good one. A definite policy is necessary to head off the likelihood that, because wood is cheap, easy to work, and always at hand, considerable combustible material will be added rather than removed.

4. In the following sections, some of the previously mentioned phases of the problem are treated in greater detail:

VERTICAL OPENINGS.

5. The unenclosed vertical opening is a serious menace in the majority of existing buildings. Unfortunately, it is not properly safeguarded in many structures being erected today.

6. Some of America's greatest disasters in factories, hotels, clubs, and lodging houses have been directly attributable to the unprotected vertical opening, and in fires in which one or more persons lose their lives, the rapid upward spread of fire and smoke through unprotected vertical openings is generally the chief reason for inability to escape or to be rescued.

7. The potential hazard in such buildings as department stores, where open elevators and stairs and occasionally open light wells exist, is unquestionably great. The smoke from a fire which sprinklers are controlling might spread panic through such a structure.

8. It is not an exaggeration to say that one of the chief causes of our conflagrations is the unprotected vertical opening, for in buildings poorly constructed, filled with combustible material, and connected floor by floor, a number of our conflragrations have had their beginning. Baltimore is a well known example.

9. The effect of the unprotected opening is two-fold: first, the existing draft intensifies the fire in the story where it has broken out; and, second, fire and smoke rapidly spread upwards. No fire department, no matter how efficient, can be expected to prevent a serious loss in our ordinary mercantile building if fire once has a start.

10. In the chapters in this book devoted to structural features a number of references will be found to proper forms of construction to overcome the hazard of the unprotected vertical opening. Summarized, the essential features include:

SHAFTS.

In General.

11. To be of brick, concrete, terra cotta, gypsum blocks, plaster on expanded metal, or plank or double match boards, depending upon the structural conditions. City building requirements or factory safety standards will frequently decide the type of enclosure to be used. Generally speaking, it is only necessary that the vertical enclosure have fire-resisting power equal to the floors, unless the shaft is to be a safe place of refuge for the occupants, in which case effective fire-resisting enclosures are essential.

Stair Enclosures.

12. Three forms of stair enclosure have been used, the smoke-proof stair tower, the ordinary stair in a shaft, and an enclosure of all or a portion of each flight, so that while fire will probably be prevented from spreading upwards, persons coming down have to pass into each story to leave the building. Fig. 149, on page 646, illustrates forms of smoke-proof stair shafts and Fig. 29 shows stair shafts of the other two types. The third method obviously is objectionable from a life standpoint, and would prevent a stair so protected from

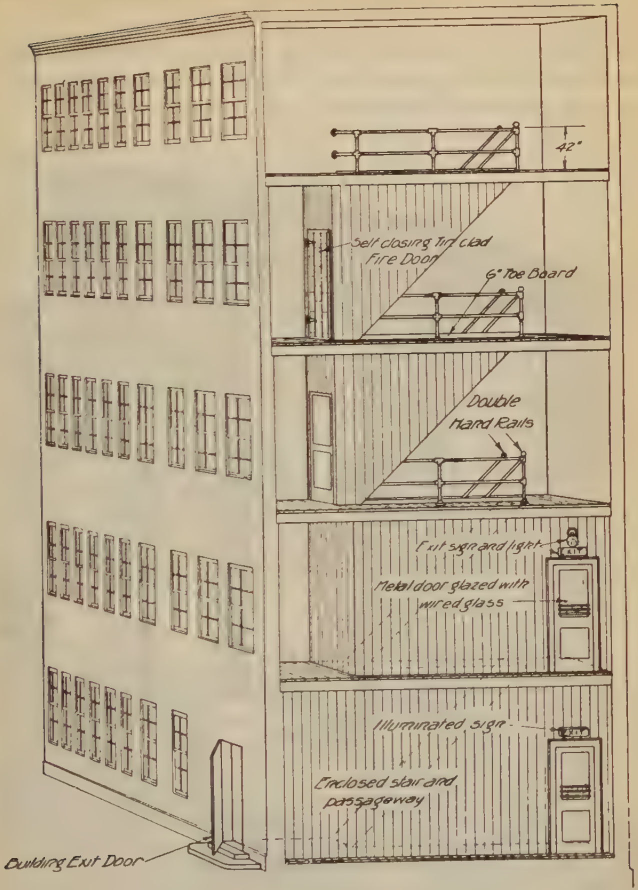

42"
Self closing Tin clad Fire Door
6" Toe Board
Double Hand Rails
Exit sign and light
Metal door glazed with wired glass
Illuminated sign
Enclosed stair and passageway
Building Exit Door

FIG. 29. ENCLOSURES FOR STAIRS.

Showing Non-standard Enclosure in Upper Two Stories and Standard Exit in Lower Ones.

being classed as an approved exit in a number of our more progressive states.

13. In Fig. 29 attention also is called to the properly dimensioned handrail on each side of stairs, to the 6″ toe-board designed to prevent material from rolling down the stairs

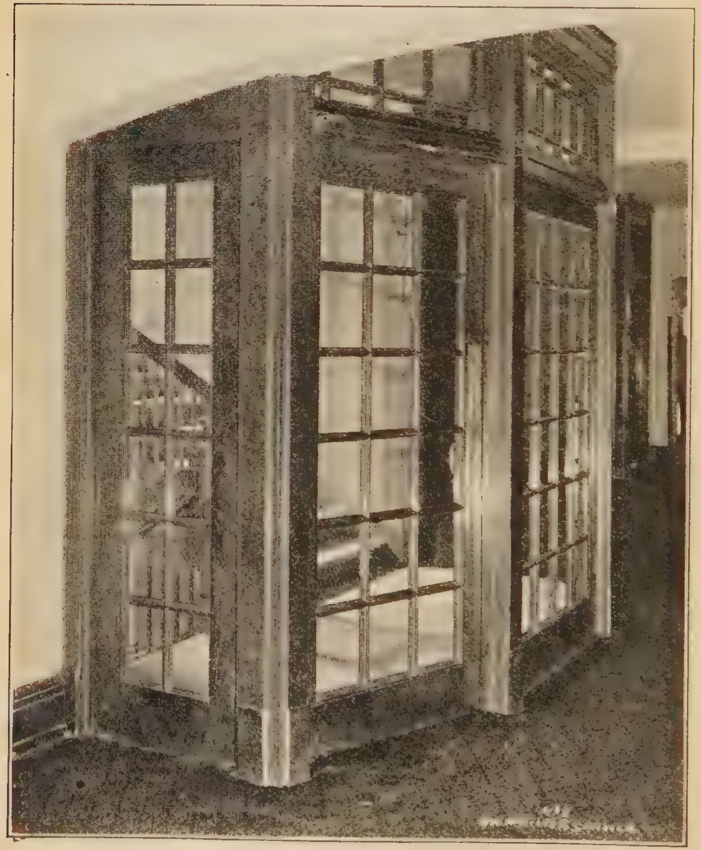


Fig. 30. Metal Frame, Wired Glass Stair Enclosure with Fusible Links for Doors

(Courtesy of Chalfonte, Atlantic City)

from the side, to the signs and illumination, and to the direct exit to the outside of the building.

Fig. 30 illustrates a stair enclosure of metal and wired glass.

Doors.

14. For types of doors and for conditions under which they can advantageously be used, see page 224. Doors should have fire-resisting power at least equal to the enclosures.

Shaft Openings Other than Doors.

15. These should be permanently closed up in so far as possible. Windows can best be stationary, and of the metal frame wired glass type. Shutters frequently are advisable for such openings.

TRAP DOORS.

16. Counterbalanced stair trap doors are considered a decided life menace where there are any appreciable number of persons in the building, in that trap doors may fall and strike persons, and particularly because they may be locked from below and bar exit altogether, as in the disastrous Diamond Candy Co. fire in Brooklyn in 1915. Even if a trap door is not locked from below, persons rushing onto it from above would prevent it from being opened. See Fig. 150, page 649.

17. Elevator trap doors have been rather commonly used, and are operated either by the car in its rise and descent, or are normally held open and controlled by fusible links. Unless the shaft is well enclosed and guarded with safety gates such trap doors are exceedingly dangerous. Also their upkeep is generally troublesome. A combination of better fire protection, greater safety, and less upkeep trouble frequently causes the enclosed shaft to be selected even if the cost is higher. See page 12.

LIGHT WELLS.

18. From a fire standpoint, the best and generally the cheapest solution is to floor over light wells. If they must remain, they should have fire-resisting walls and wired glass windows.

NEEDLESS OPENINGS.

19. Holes around pipes, ducts, chutes, and other comparatively small equipment can be and should be closed up tightly. Many a building has suffered greatly increased fire loss because a single apparently insignificant hole permitted fire to spread upwards or sideways, or because serious water damage resulted on floors below.

BELTS.

20. Belts tend to carry fire upwards with great speed because of draft set up by them, oil and dust likely to accumulate near them, and their own combustibility. Proper belt treatment includes:

a—Drive belts in separate tower connected to each floor by shafting passing through solid walls. See Fig. 22, page 157.

b—Inter-floor belt system entirely enclosed in non-combustible housing, such as metal lath and plaster. Even a wooden enclosure, kept clean, and especially if protected with sprinklers, is far better than a series of open holes.

c—Pulleys and belts at ceilings driven from above, or near floors driven from below, housed in metal.

d—Automatic dampers cutting off belt hole areas, and operated by fusible links.

e—Reducing floor holes to a practical minimum, providing metal rollers or other metal guides to prevent belt cutting floor, if of wood, and providing curtain boards extending well below ceiling. This is particularly effective when sprinklers are installed.

CHUTES AND DUMB WAITERS.

21. Treatment similar in principle to previously described methods of procedure is advisable for chutes, dumb waiters, and conveyors. Vertical sliding doors with fusible link control are commonly used on dumb waiter openings. The fire which destroyed the Equitable Building in New York started in the basement at the foot of a wood-lined open dumb waiter shaft. It spread upward with tremendous speed, struck the roof, mushroomed, and worked down, in part at least. Six lives were lost and millions of dollars worth of property destroyed because a single dumb waiter shaft was not up to a reasonable fire safety standard.

CONCEALED SPACES.

22. In so far as possible, concealed spaces should be avoided in new construction for factory and mercantile buildings and should be eliminated in existing ones. The danger lies in the rapid and practically uncontrollable spread of fire in unstopped joist channels, behind wood furring, in wood stud partitions, in hollow cornices, and in other similar types of construction.

23. Attics very frequently are not necessary. This is particularly true where they are produced by sheathing underneath the roof trusses and are not used for storage or any other purpose.

24. These spaces are generally exceedingly dry, likely to accumulate refuse and dust, and it is practically impossible to get into them in case of fire. The removal of sheathing and finish, especially if it is combustible, is almost always advisable. If exposed joists, trusses, roof boards, or other members are cleaned and then liberally whitewashed or painted the appearance will generally be satisfactory. While attractive appearance may be produced by sheathing, fire safety by all means should come first.

25. Where sheathing is fastened to nailing strips, which in turn are secured to the underside of joists, the entire ceiling area may be open to rapid fire spread. Replacing with incombustible ceilings directly against the joists, or providing an elaborate system of stops, is the only answer to the problem other than removing sheathing altogether.

26. If sheathing of wood lath and plaster must remain, having it tight so that fire cannot readily get into joist channels or other concealed spaces is a step in the right direction. Furnace tests at Underwriters' Laboratories have indicated that wood lath and two coat lime plaster will serve as a barrier to fire into stud channels (same thing undoubtedly will be true of joist channels) for about four minutes. A far better method is to apply metal lath and plaster (three coat, approximately ¾″ thick, wood fibred or sanded gypsum) which Underwriters' Laboratories tests have shown capable of withstanding intense fire for as much as an hour. Such protection can be placed over old sheathing if desired.

27. Where joist channels or box cornices are not over 20 to 30 ft. long, it is not necessary to break into them and introduce draft stops. For a length greater than 30 ft., however, it is advisable to provide stops at intervals of about 30 ft., and preferably to have them incombustible.

28. Metal ceilings are inadvisable, as they readily get hot enough to ignite wood behind them and are difficult to tear off at time of fire. If backed with plaster board, metal is less objectionable. At the Ward's Island Hospital fire of February, 1923, sheet metal ceiling that had been placed under wood lath and plaster fell from the corridor ceiling in a large "blanket" and was the principal cause in the loss of 26 lives.

29. Stud partitions should, where superimposed in two or more stories, be effectively stopped off at each floor line, including the attic level, if any.

30. See pamphlet of the N. F. P. A. entitled "Structural Defects" for excellent illustrations and various ways of introducing fire stops.

COMBUSTIBLE CONSTRUCTION.

31. Closely allied to the previous section of this chapter is the question of getting rid of the combustible construction.

32. Expanded metal on steel or on wooden studs makes an excellent enclosure for a tool room or storeroom. Such an enclosure is entirely or practically incombustible, can be seen through, fire streams can be directed through it, and locking up power is retained.

33. Metal storage bins, especially when additional capacity is needed, will often cost little, if any, more than wooden ones, especially when greater capacity, greater strength, and longer life are taken into account.

34. Rooms no longer needed and unnecessary partitions, cupboards, storage shelves, benches, and similar combustible material are frequently found in modern plants and can be removed.

35. Combustible roof structures are a menace and often can be replaced by metal frame, wired glass skylights, or by a metal ventilator or two. One building in the San Francisco fire, effectively protected by shutters, was destroyed by fire which ignited a combustible roof structure.

36. Many important buildings are seriously jeopardized by adjoining sheds and by small frame connecting buildings or bridges erected between two important structures. These creep in almost unnoticed as plants grow, and are often a serious menace. Reconstruction or definite fire cut-offs are the remedy.

37. For especially hazardous sections such japan and varnish rooms and others where volatiles, paints, or other highly inflammable materials are used, fire-resistive construction or the provision of effective fire-resisting coverings for woodwork are often good policy. Wood covered with two layers of ½″ air cell asbestos board, staggered, nailed on firmly with tin caps under the nails, or covered with metal lath and plaster is acceptable construction.

CORNICES.

38. With a combustible cornice, the first consideration should always be whether or not it can be entirely removed, or if necessary for architectural purposes, replaced with incombustible material. Other possibilities are:

a—Covering it with metal, preferably over asbestos paper ⅛″ or thicker.

b—Cutting it off, particularly at fire walls, by corbelling out brickwork at least 8″ thick or equivalent means. See Fig. 23, page 159.

c—Stopping it off every 30 ft. by means of incombustible materials.

OVERHANGING ROOFS.

39. Overhanging roofs seriously exposed are a decided danger. The best procedure, if feasible, is parapetting the wall and securing drainage inside of the building walls. An alternative is to cut roof off flush with the wall and to provide a metal gutter.

WOOD SUBSTITUTES AND TREATED WOODS.

40. There are certain non-combustible compounds, chiefly asbestos and cement, which are occasionally used as substitutes for wood. These materials can be worked with tools and from their nature are, of course, superior to wood from a fire standpoint. They are not, however, commonly used or generally considered to be commercially practical.

41. Many attempts to treat wood to make it capable of successfully resisting fire have been made, and a few of such treated woods marketed, especially in New York City. The United States Government is reported to have used them in the navy. Many factors are important in judging the value of such a product, and it may be generally stated that a false sense of security would exist if most types were used. With the rapid development of non-combustible finishes, through the use of metal lath and plaster, and through the use of metal windows and metal door frames and doors the need of treated wood has gradually fallen away.

42. The Forest Products Laboratory of Wisconsin made a most comprehensive series of tests on the inflammability of untreated wood and of wood treated with different fire-retarding compounds. The N. F. P. A. published these tests in 1915. The report is exceedingly interesting and conclusive. Many forms of impregnating solutions were tried and nine different soft woods tested, in block, siding, and shingle form. Among the general conclusions reached were:

a—Ammonium salts and sodium borate gave best results.

b—If shingles are impregnated (except with insoluble metallic borates) they must be painted to keep chemicals from leaching out.

c—Various fire-retardant paints tested gave some protection. Zinc borate was best for outside paint.

d—Staining shingles does not greatly increase their inflammability.

e—Interior use paints generally have better retarding ability than those for outside use.

FIRE-RETARDANT PAINTS.

43. It is an absolute misnomer to refer to fire-retardant paints as fire-resistive. At best they have ability to retard the spread of fire to a limited extent only. See paragraph 42, above.

44. For many years wood will be an important factor in building construction, and as wood surfaces aid in the quick spread of fire, the problem of making these surfaces fire-retarding to the extent that fire must penetrate the surface before finding a combustible on which to feed, needs careful study.

45. A paint or similar coating which can be applied with a brush is so much cheaper than a coat of metal or plaster or than other non-inflammable materials that it can be freely used where other methods are generally too expensive. While therefore it should be fully understood that these surface coatings are merely fire-retardants, and do not in any sense make woodwork fire-resistive, they should be given consideration in that they render inflammable surface less susceptible to the spread of fire.

46. Furthermore, this class of paints is far preferable to varnish, shellac, or oil, and should be encouraged to the exclusion of such inflammable coatings. Ordinary whitewash is a good fire-retardant when first applied, but as with most fire-retardant paints it tends to flake off with age, and frequent renewals are necessary. Its cheapness is in its favor.

47. What is known as Government whitewash is a more complex coating, but when properly applied gives excellent results, and is the equal, if not the superior, of many of the so-called "fire-resistive" paints. It is made and applied as follows:

Slake one half bushel of unslaked lime with boiling water, keeping it covered during the process; strain it and add a peck of salt dissolved in warm water; three pounds of ground rice, put in boiling water and boil to a thin paste; one half pound powdered Spanish whiting and a pound of clear glue dissolved in hot water; mix these well together and let the mixture stand for several days. Keep the wash thus prepared in a kettle or portable furnace, and when used put it on as hot as possible with painter's or whitewash brushes.

48. A simpler whitewash which, when properly made and put on, gives a white that does not easily wash or rub off is as follows:

To ten parts of best specially slaked lime add one part of best hydraulic cement; mix well with salt water and apply quite thin.

49. Fire-retardant paints are generally cold water paints and compounded on various "secret" formulas. They consist chiefly of a fire-retardant chemical with a binder, such as glue or casein. This latter material which is obtained from curdled milk is used in a number of the better known fire-retardants, and apparently is effective in increasing the life of the coating.

50. An effective out-door paint developed[*] by the Forest Products Laboratories of the United States Forest Service consists of linseed oil, zinc borate, and chrome green. This paint has retained its fire resisting properties through more than three years of exposure to the weather.

CHAPTER 14

ROOFS AND ROOF COVERINGS

INCOMBUSTIBLE ROOF CONSTRUCTION.

1. For many buildings there is need of a light-weight, low-cost, non-combustible roof in distinction to an expensive fire-resistive roof construction, with supporting steel insulated against heat. For machine shops, foundries, power houses, and other structures which contain little that is combustible, a roof that in itself will not burn is frequently sufficient.

2. The use of a plank roof on such buildings, even if carried on steel trusses and purlins and covered on the weather side with a non-combustible roofing, is attendant with some hazard, unless sprinklered. If the underside of plank is effectively protected with metal lath and plaster, the expense is considerable, and there is some possibility of dry rot.

3. The following forms of non-combustible (not fire-resistive) roof construction are more or less commonly used and are all carried on unprotected steel.

a—Concrete slabs on steel, and covered with felt, pitch, and tar or gravel, or with slate, or tile.

b—Terra cotta tile or gypsum monolythic or slab construction, similarly covered.

c—Asbestos protected corrugated iron.

d—Galvanized corrugated iron.

e—Ordinary tile or slate resting on and attached to steel purlins and trusses.

f—Reinforced Portland cement tiles of fairly large area, laid on steel. These require no covering, as surfaces are finished to withstand the weather.

g—Corrugated zinc.

h—Corrugated wired glass.

4. Of these "a" and "b" are unquestionably best from an operating standpoint, require little attention, and tend to avoid condensation. Gypsum slabs are the lightest and have the highest insulating efficiency.

c—Corrugated iron protected with asbestos and covered with a waterproof outer layer, all tied together with a strong binder, has had wide use, especially where corrosive conditions exist.

d—Galvanized corrugated iron is popular, especially in steel mills and similar plants. It must be securely fastened, and painted at intervals or replaced as corroded.

e—Ordinary tile or slate directly on steel are not extensively used. Condensation is produced by differences in temperature inside and out, members may be lifted by wind or frost, fire streams may dislodge the covering, cracking of slate is frequent, and persons cannot walk on such roofs with safety.

f—Reinforced Portland cement tiles are subject to the same defects set forth in "e." Flaking off of the thin layer of cement on the under side has permitted corrosion of the reinforcing, tiles have fallen, and men have been killed by going through them.

g—Corrugated zinc, a by-product of the large production of zinc during the war, is enjoying some vogue, as a roof and wall covering. It has merit as far as incombustibility and freedom from certain corrosive influences are concerned, but it is structurally weak, melts at about 800° F., and must be insulated from a steel structure to avoid electrolytic action. Used as a covering for a wood deck, zinc should be more effective than in corrugated sheets of some span.

h—Corrugated wired glass, with corrugations to fit those of standard corrugated iron, has now had sufficient field experience to indicate its value as an economical means of increasing light in certain types of buildings. It is used in walls as well as roofs.

5. Where roofs are of metal construction, or even where the building frame only is of metal, it is advisable to ground the building effectively as a protection against lightning.

6. There have been several notable fires where the only large quantity of combustible material in the building destroyed was in the form of planking in the roof. Such roofs, ignited by a small fire, have, in burning, heated steel trusses sufficiently to cause their collapse, and practically the complete destruction of buildings and contents has resulted. Similarly a non-combustible roof can readily suffer serious damage if combustible material burns below it. Where exposed steel trusses are used, combustible storage, office enclosures, etc., should be eliminated.

ROOF COVERINGS.

7. The tabulation on the next page shows the essential facts regarding the classification of roof coverings, as established by Underwriters' Laboratories after extensive furnace tests. These roofings are all designed to afford adequate protection to a wooden roof deck in varying degrees (severe, moderate, and light exposure) against radiated heat, flying brands, and the carrying or communicating of fire by the roofing itself. Of course, a given roof covering can if desired also be used for a less severe exposure than the one for which it is approved. There are large numbers of manufacturers of approved roofing spread over a wide territory, and only labeled roofing should be installed.

8. While the Laboratories have not rated certain other roof covering for wood decks, the following would seem to accord with the spirit of the classification.

Class A (Severe) slate and tile.
Class B (Moderate) metal sheets or metal shingles laid over asbestos paper, not less than ⅛″ thick.
Class C (Light) metal sheets or shingles of copper, tin, and zinc laid directly on wood.

Advisable Use.

9. For concrete, hollow tile, or gypsum roofs, which require a covering and which are approximately flat, a good quality of built-up roof is used almost universally. While a gravel or slag surface can be laid on fairly steep slopes if asphalt is used for imbedding the surfacing material, a rise of 3″ in 12″ is generally considered the advisable limit of steepness.

TYPES OF ROOFING AND SITUATIONS FOR WHICH SUITABLE

Item No.	Impregnating Material.	Felt.		Surfacing Material.	Maximum Slope in 12″.	Class of Roofing and Exposure.		
		Material.	Minimum Plies.			Class A Severe.	Class B Moderate.	Class C Light.
		Built Up Roofing.						
1	Tar	Rag	4	Pitch-gravel, slag, stone	3″	×		
2	Asphalt	Rag	3	Asphalt-gravel, slag, stone	3″	×	×	
3	Asphalt	Asbestos	3	Smooth-cemented to deck with Asphalt	12″	×	×	
4	Asphalt	Rag	2	Smooth or Grit	12″			×
		Prepared Roofing.			Minimum Slope in 12″.			
5	Asphalt	Asbestos	4	Smooth Nailed	4″	×		
6	Asphalt	Asbestos	2 and 1	Smooth or Grit	4″		×	
7	Asphalt	Rag	1	Smooth or Grit	4″			×
		Shingles.						
8	American Method	Cement and Asbestos	2		4″	×		
9	French and Hexagonal	Cement and Asbestos	1		4″		×	
10	Asphalt	Asbestos	1	Smooth and Grit	4″		×	
11	Asphalt	Rag	1	Smooth and Grit	4″			×

Note: Roofings are approved by Underwriters' Laboratories based upon tests rather than specifications; hence the above table will not always accord with the list of approved roofings. In a number of instances roofings with one ply felt less have been approved over incombustible roof decks.

10. For steeper roofs, slate, tile, metal, prepared roofing, asbestos shingles, or asphalt shingles with slate surface are advisable.

Wood Shingles.

11. A large part of the tremendous loss by exposure, shown in table on page 30, has been due to the wood shingle roof. The Baltimore conflagration was one of the few in which the wooden shingle did not play a vital part. It was a factor in San Francisco. It was the principal factor in such conflagrations as Arverne, N. Y., Austin, Texas, Atlanta, Ga., Bangor, Me., Jacksonville, Fla., Nashville, Tenn. Paris, Texas, and Salem, Mass.

12. Franklin H. Wentworth, Secretary of the National Fire Protection Association, puts the case of the wood shingle in the following words:

13. "The prohibition of the wood shingle roof, which is now generally recognized as a conflagration breeder, is today almost universal within city fire limits, and from the more enlightened communities it is excluded altogether. Burning shingles can be carried great distances by the wind or draft of a conflagration, and when they alight in their turn upon other dry shingles, they make fearful havoc.

14. "It is not necessary to remove all wood shingles immediately. Effective city ordinances, now in force in over one hundred communities, require all roof construction in the future to be capable of effectively resisting radiated heat and sparks and brands, and of not propagating fire. Furthermore, it is required that all roofs which hereafter require repairs to the extent of a substantial portion of their area (frequently one third) shall be replaced with a safe type of roof."

15. Up to the present time, the proposal so to treat wooden shingles that they lose their fire hazard has not worked out in a sufficiently satisfactory manner to warrant the general endorsement of "treated" wooden shingles.

SKYLIGHTS.

16. The rules of the National Board of Fire Underwriters governing Roof Openings, Cornices, and Gutters cover in detail the following forms of construction:

Monitor or lantern skylights.

Saw-toothed skylights.

Vertical sash under raised sections of roofs.

Ventilating skylights or skylight sash.

Windows in roof structures.

Dormer windows.

Skylights on stair elevator, dumb waiter, light, air, and similar shafts.

Theater stage skylights and ventilators.

Ventilators.

Door landings, pent houses, or bulkheads.

Scuttles.

Open air or light shafts.

Cornices and gutters.

.The gist of the rules is as follows:

17. Glass. (a) For plane skylights or such as are inclined less than 80 degrees to the horizontal, except as noted under (b) and (c), approved wired glass not less than ¼-inch thick or ⅛-inch plate glass protected with approved wire screens shall be used. The panes must not be over 18 inches wide and must not exceed 1,728 square inches in area.

Where skylights inclined at an angle of 80 degrees or more to the horizontal are subject to exterior exposures approved wired glass not less than ¼-inch thick shall be used. For such sash the unsupported surface of the glass shall not be more than 48 inches in either dimension or exceed 720 square inches in area.

(b) For skylights over stair, dumbwaiter, air or similar shafts, glass not over 3/16-inch thick shall be used, not over 18 inches wide, nor more than 720 square inches in area, protected with approved wire screens.

(c) For skylights over stage sections of theatres, not over ⅛-inch glass shall be used, protected by suitable screens.

Note—Substitutes for glass, such as wire cloth with a coating of translucent, combustible substance or similar material, are not approved.

18. Special attention is called to the thin glass requirements over fire-resistive shafts and over theater stages. It is desired rapidly to secure ventilation in the case of fire-resistive shafts, so as not to drive fire and smoke horizontally into the other stories. In the case of theaters, ventilation is vital to prevent gases being driven through the proscenium arch into the auditorium.

19. Sash and Frames—To be entirely of galvanized iron or copper.

20. Glass to be secured to the sash by means of metal strips held in position by bolts or screws in such a manner as to form joints sufficiently elastic to allow for proper expansion and contraction, and to be weather-proof.

21. Screens—To be of woven, galvanized wire, not lighter than No. 12 gage, and with mesh not less than ¾″ or over 1 inch. To be firmly supported on iron rods or angles, placed 4 to 10 inches from plane of glass, and to project beyond the edges a distance equal to that above glass.

22. The modern tendency, both to secure fire and life safety, is to use wired glass. Where plain glass is used, screen protection above is required to guard against brands, and below to protect persons from falling glass.

23. Where skylights or other openings are used for ventilation, the screen used should be able to keep out sparks. ¼-inch mesh is recommended.

24. Especially protected metals are now available for sky light construction to protect against corrosion, both from the elements and from chemical fumes.

VENTILATORS.

25. Discharge pipes or flues, delivering air, gas, or vapors by mechanical means are not covered by these rules. All other forms of natural draft ventilators, whether stationary or pivoted, are covered, including louvres and ventilating monitors. The essential safeguards from a fire prevention standpoint are:

a—Incombustible construction of the ventilator itself.

b—Design which will not permit sparks or brands to fall or drift into the building, which result may be achieved by baffle plates, vanes, or dampers, or by metal screens of not more than ⅜″ mesh.

c—Where unusual corrosion conditions exist, protection superior to that of a good quality of galvanized iron can be secured by the use of a specially protected metal.

CHAPTER 15

PROTECTION OF OPENINGS IN WALLS AND PARTITIONS

1. In this chapter are treated methods of protecting against fire openings in exterior and interior walls and in vertical enclosures, such as elevator and stair shafts and light wells.

CONDITION OF WALLS

2. Before embarking on expensive protection of openings in exterior or interior walls, decision must be made, first, as to the real need of such protection, and, secondly, assuming the need, as to the condition of the walls in question. A portion of the first question is whether the money required for protection of wall openings could not be used more effectively, as, for example, installing automatic sprinklers in a building only *mildly* exposed. That building would then be effectively protected against internal fire and to a considerable degree also against exposure.

3. Some of the situations found with respect to walls are as follows:

EXTERIOR WALLS.

a—Ability to close up all or a portion of wall openings where exposure is very severe, even occasionally if changes in natural illumination are necessary or artificial illumination must be provided.

b—Overhanging wooden roofs or cornices, which are generally the first to ignite from an exposing fire.

c—Combustible roof structures or roof covering which fire could attack.

d—Shipping platforms, roofs over platforms, passages to other buildings, or other combustible construction which must be cut off, if protection against exposure is to result.

e—Opportunity for fire to get under buildings, especially if burning inflammable liquids might be involved.

INTERIOR WALLS.

f—Ability to get along with fewer doors in division walls.

g—Ability to reduce division wall door openings in area.

h—Walls fairly close together so that it is not necessary to make an effective fire wall out of every brick wall. It is better to have a first-class wall at intervals than several sub-standard ones.

i—Ineffective parapet or no parapet, calling for an effective roof cut-off if a good fire wall is to result. Where not effectively cut-off at roof, single doors on each opening instead of double doors often are sufficient.

j—Relation of fire sections such that even if wall openings are effectively protected, fire may sweep around or over walls or through light courts, or spread because of differences in roof levels, wooden additions or roof structures, etc.

k—Timbers let into walls from one or both sides, so as either to touch or to leave weak spots for passage of fire.

l—Timbers for floors or roofs not self-releasing, making likely a tearing down of a portion of wall or opening of hole through wall, should one section collapse.

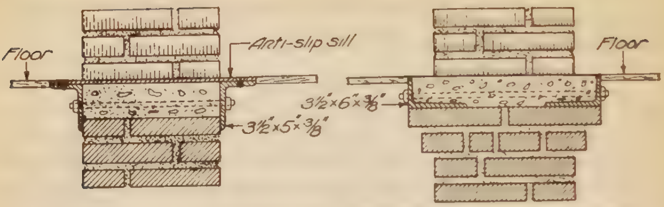
m—Weak portions of walls due to insufficient thickness, patching, or settlement, making local failures likely.

n—Ventilating ducts, piping, shafting, or other equipment passing through walls and weakening their fire-resisting ability.

PREPARATION OF WALL OPENINGS

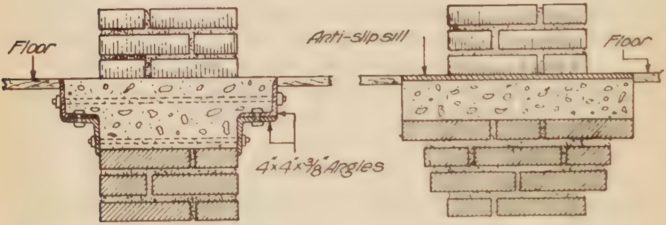
4. A vital weakness in supposedly protected wall openings is the presence of combustible material in the opening proper or close thereto. Particular attention is called to the following:

a—Necessity of an incombustible sill for openings in exterior or interior walls, which are protected with fire doors. See Fig. 31. Labeled anti-slip material for fire door saddle represents the best practice.



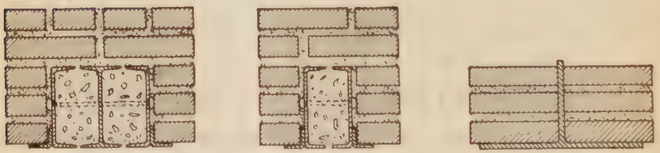
ANGLE IRON AND CONCRETE SILL WITH ANTI-SLIP TOP

ANGLE IRON AND CONCRETE SILL ON A CORBEL OF TWO COURSES OF BRICK



Z BAR AND CONCRETE SILL

CONCRETE SILL WITH ANTI-SLIP TOP



STEEL LINTEL

STEEL LINTEL

CAST IRON LINTEL

FIG. 31. FIRE DOOR SILLS AND LINTELS

b—Elimination of wooden lintels or door frames from such openings.

c—Elimination of combustible finish from vicinity of wall openings.

d—Use of noncombustible fire door guards. See Fig. 35.

e—Elimination of wooden trim behind metal fire windows, where commonly used in even recently finished buildings.

f—Keeping storage racks and goods at least 3 ft. from windows protected against exposure.

g—Use of steel wall frames securely fastened in openings for the attachment of swinging doors of various designs.

FIRE DOORS

5. Fire doors are used principally to protect openings in division walls and on shafts, although where wired glass or shutter protection is installed on windows, fire doors become necessary on exterior door openings as well. Fire doors have been in use for decades, and, in spite of much poor design, construction, and installation, have on the whole given a good account of themselves. Modern approved fire doors, properly installed and shut, have astonishing fire-resisting powers. The Underwriters' Laboratories' test requirements for doors designed to be used in different situations, and therefore presumably subject to different durations and intensities of fire, are more severe than are ordinarily experienced in fires, giving a margin of safety. See Fig. 32.

PROPER DOOR TO SELECT.

6. The National Board Rules on Protection of Openings in Walls and Partitions cover six forms of door construction and six situations for which protection of different degrees is required. Furthermore, these forms of construction are found used in horizontal sliding, swinging, vertical sliding, rolling, and counter-balanced designs. Two forms of approved wired glass window frames are also included in the Rules.

In table on the next page appear the essential facts as to what is approved by National Board Rules, and what the

PROTECTION OF OPENINGS

Line No.	Column 1	2	3	4	5	6	7
	Type of Construction	Nat'l Board Retard. class	Forms in which commonly used				
	FIRE DOORS AND SHUTTERS		Sliding	Swinging	Counter-balanced	Rolling	Shutters
1	Sheet metal	A	√	√			
2	" "	B	√	√	√		
3	" "	C	√	√			
4	" "	D		√			√
5	Tin clad—3 ply	A	√	√			
6	Tin clad—2 ply	B	√	√	√		
7	" " "	C	√	√			
8	" " "	D		√			√
9	Rolling steel	A				√	
10	" "	B				√	
11	" "	C				√	
12	" "	D				√	√
13	Steel plate	A	√	√			
14	" "	B	√	√	√		
15	" "	D		√			√
16	Hollow metal	A		√			
17	" "	B		√			
18	" "	C		√			
19	" "	D		√			√
20	Metal clad	B		√			
21	" "	C		√			
22	Counterbalanced doors	B			√		
	FIRE WINDOWS						
23	Hollow metal frames	E					
24	" " "	F					
25	Solid metal frames	E					
26	" " "	F					

Note. Wired glass panels permitted in Class C Sheet Metal, Hollow Metal, and Metal Clad Doors. Wicket Doors, not over 10 sq. ft. in area, permitted in Sheet Metal Fire Doors under certain conditions.

IN WALLS AND PARTITIONS.

8	9	10	11	12	13	14	
Situations for which Retardants are Approved, and Recommended Practice							
Class A	Class B	Class B	Class C	Class D	Class E	Class F	Line No.
Division Walls	Elevator Shafts	Stair Enclosures	Corridor and room Partitions	Severe Exposure	Moderate Exposure	Light Exposure	
AG 1							1
	AG 2	AG 2					2
			AG 2				3
				AG 1	AG 1	AN	4
AG 2							5
U	AG 3	AG 3					6
			AG 3				7
				AG 2	AG 3	AG 3	8
AG 3							9
	AG 2	AN					10
			AG 4				11
				AG 2	AG 2	AN	12
AG 3							13
	AN	AN					14
				AN	AG 2	AG 2	15
AG 2							16
	AG 3	AG 1					17
			AG 1				18
				AN	AN	AN	19
U	AG 4	AG 4					20
			AG 4	U	U	U	21
	AG 1						22
U	U	U	A	U	AG 1		23
U	U	U	A	U	U	AG 1	24
U	U	U	A	U	AG 1		25
U	U	U	A	U	U	AG 1	26

Note: A—Approved for use in situations shown.
G—Good practice to use in situation shown.
N—Not good or not usual practice.
U—Unapproved or unsuitable for use.

authors consider advisable practice. In connection with this table, which will warrant very careful study, the following is submitted:

a—In the right-hand half of the table, Columns 8 to 14, many gaps simply result from following established practice. For example, Line 5, 3-ply tin-clad doors. These are approved for fire wall duty. Of course, they also would pass for Classes B to F, but 2-ply doors will answer, and the more expensive door is not listed beyond Class A. Speaking generally, any protective covering not barred by design can be used for any class of protection less severe than the class for which it is specifically approved.

b—The relative ratings of protective coverings for different situations, Columns 8 to 14, indicated by figures are those of the authors and not any formal decision of the N. F. P. A. or the Laboratories. While such a classification is obviously debatable, the general conclusions indicated are without doubt correct. For example, for fire wall duty the sheet metal door is superior to one consisting of a single steel plate.

c—In establishing these ratings, other factors other than pure fire-resisting ability have been considered. For example, for elevator shafts the counter-balanced door is placed first because of combined fire and accident merit. As a matter of fact, such a door may be made of any one of several forms of construction.

d—While the National Board Rules class protection of all vertical openings in the same manner, the chief divisions, namely elevators and stairs, have been given separate columns because the treatment is quite different.

e—The term "counterbalanced" does not apply to a rolling shutter, although such a shutter is counterbalanced by springs. Vertically sliding counterbalanced doors and elevator doors counterbalanced on each other are both included in the tabulation under the heading of "Counterbalanced."

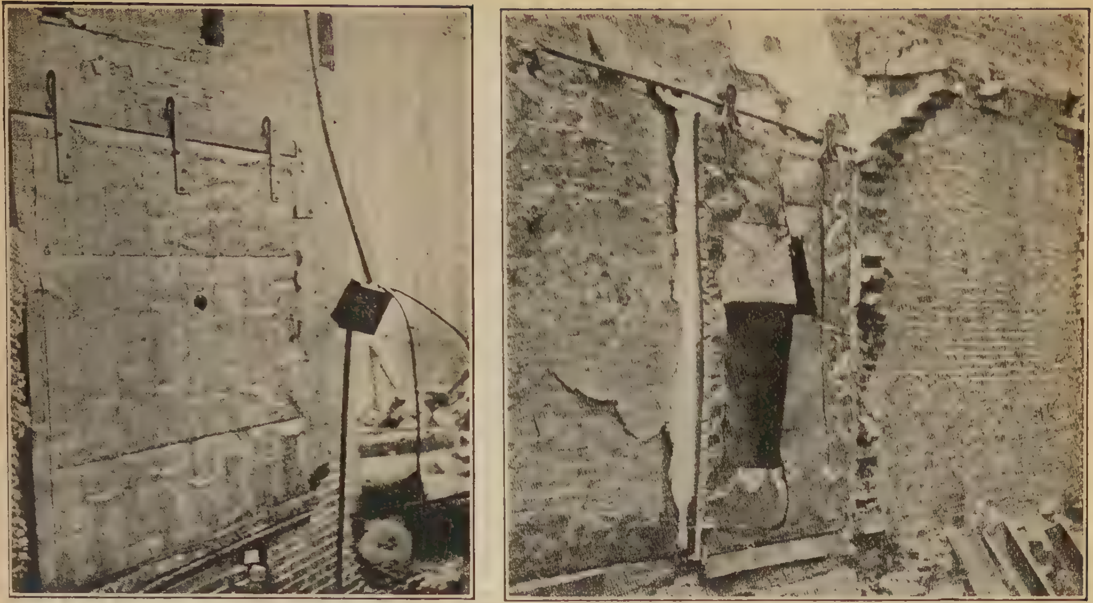


Fig. 32. Tinclad Fire Doors Subjected to Severe Exposure.

Standard 3-Ply Door with Lock-Jointed Tin. Sub-Standard Door with Hook-Jointed Tin.

MAXIMUM SIZES OF RETARDANTS.

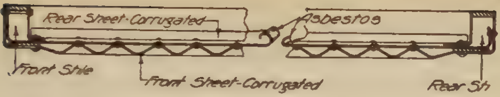
While there is some inconsistency between the National Board Rules and the practice of Underwriters' Laboratories as to maximum areas and dimensions of fire doors, the following tabulation gives the limits that can be used in considering which retardant to employ for a given situation:

Type of Construction.	Maximum Area.	Dimensions in Feet. Width.	Height.
Fire Doors.			
Sheet Metal	120	10	12
Tin Clad	120	10	12
Rolling Steel	80	12	12
Steel Plate	80	8	10
Hollow Metal	80	8	10
Metal Clad	80	8	10
Fire Windows.			
Severe Exposure	50	5	10
Moderate Exposure	70	7	10

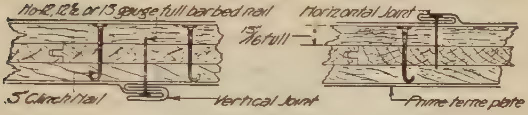
7. Having determined the type of door construction to be employed, the question arises (except in the case of rolling shutters and counterbalanced doors) as to which form shall be used: horizontal sliding, swinging, or vertical sliding. Two factors here enter, first, likelihood of door being closed at time of fire or of closing automatically, and, second, whether a certain form, as swinging, is prescribed in exit regulations which may pertain to the opening. These factors are recognized in the following sections taken from the National Board Rules:

a. **Sliding Fire Doors**—Doors of this type shall be employed unless features relating to exit facilities, service requirements, location, or installation make other types preferable.

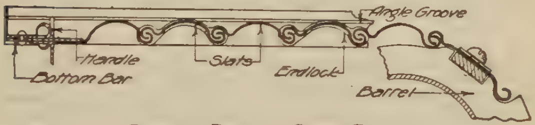
Note.—Sliding fire doors can be mounted close to the wall, require only a small amount of floor space, are less likely than many other types to be rendered inoperative by obstructions. They can be counterbalanced so as to operated without great difficulty and can be made to close automatically without the use of complicated apparatus. They are particularly suitable for large openings, but the method of operating them is not as obvious as that of swinging doors, and they are more subject to injury from falling materials at time of fire than doors that close flush with the face of the wall. They can be used only where there is sufficient wall space at the side of the wall opening.



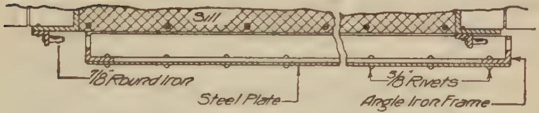
CASE 1. SHEET METAL DOOR.



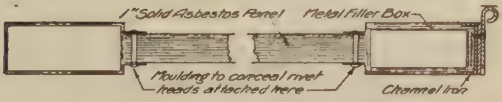
CASE 2. TIN CLAD DOOR (3-PLY).



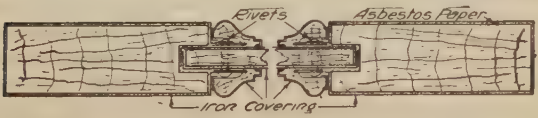
CASE 3. ROLLING STEEL DOOR.



CASE 4. STEEL PLATE DOOR.



CASE 5. HOLLOW METAL DOOR.



CASE 6. METAL CLAD DOOR.

FIG. 33. DETAILS OF FIRE DOOR CONSTRUCTION.

b. **Swinging Fire Doors**—Doors of this type may be employed where the character and size of the opening make the use of this type of door advisable. Where egress is in one direction only, the doors should open in the direction of travel.

Note.—Where egress is in one direction only, swinging doors are easier to operate than any other type of door, especially under emergency conditions. Swinging fire doors require considerable clear floor space, are more liable to be rendered inoperative by obstructions than sliding fire doors, and are difficult to make automatic without the use of complicated apparatus. Swinging doors in pairs do not furnish as satisfactory protection against fire as single doors.

c. **Vertical Doors**—Doors of this type may be employed where horizontally sliding or swinging doors cannot be used, and where the doors do not serve as exit doors at time of fire.

Note.—Vertical doors require considerable head room above the door opening and must be counterweighted to render them operative. They can be made automatic without the use of complicated apparatus. They are difficult to operate, especially after they have closed automatically, and their use in any given case should be considered in its relation to the effect upon hazard to life.

d. **Rolling Steel Fire Doors**—Doors of this type may be employed where the transmission of heat through the doors is not liable to result in the spread of fire, and where the doors do not serve as exit doors at time of fire.

Note.—Rolling doors are capable of being installed in locations where space limitations prevent the installation of other types of doors. They can be mounted flush with the face of the wall so that no floor space is required, and are less likely than many other types to be rendered inoperative by obstructions. They can be counterbalanced so as to operate without great difficulty, but the method of operating them is not as obvious as that of other types of doors, and some types of rolling doors are difficult to operate after they have closed automatically. The type and use of these doors in any given case should be considered in its relation upon hazard to life.

FIRE DOOR CONSTRUCTION DATA.

8. The essential principles of construction of the available types of fire doors, together with the chief advantages and disadvantages of each, are set forth in the following sections:

1—**Sheet metal.** (See Fig. 33.) Undoubtedly the best fire door for general purposes with rapidly growing popularity. Design usually involves corrugated steel sheets with asbestos between, riveted at right angles to each other, and mounted on a substantial steel frame.

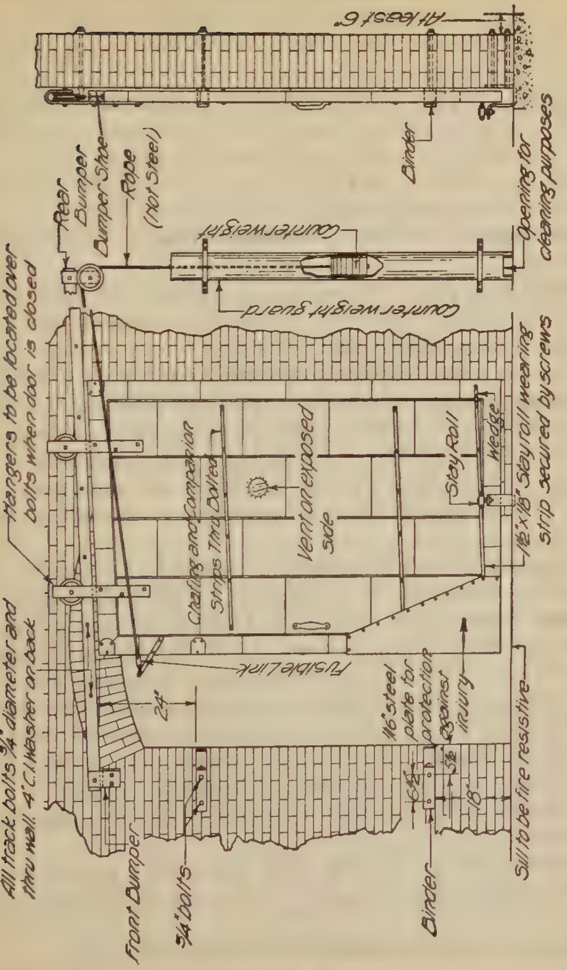

All track bolts 3/4" diameter and thru wall. 4" C.I. washer on back
Hangers to be located over bolts when door is closed
Rear Bumper
Bumper Shoe
Rope (Not Steel)
Counterweight
Counterweight guard
Binder
At least 6"
Opening for cleaning purposes
Chafing and Companion Strips Thru Bolted
Vent on exposed side
Stay Roll
Wedge
1½"x1/8" Stay roll wearing strip secured by screws
Fusible Link
24"
1/16" steel plate for protection against injury
6½"
5½"
18"
Sill to be fire resistive
Front Bumper
3/4" bolts
Binder

FIG. 34. STANDARD TINCLAD AUTOMATIC GRAVITY CLOSING FIRE DOOR

Advantages: no combustible contents; minimum upkeep trouble; longer life; lighter weight; reasonable cost.

Disadvantages: not as widely manufactured as tinclad doors.

2—**Tinclad. 3-ply.** (See Fig. 33.) The standard fire door to date. Its popularity probably will wane and doors free from combustible fillers gradually take its place.

Advantages: widely manufactured; manufacture requires no expensive mechanical equipment; moderate cost.

Disadvantages: dry rot, mechanical injury; other upkeep difficulties.

3—**Tinclad. 2-ply.** The standard shutter to date. Also used for fire door purposes, frequently where 3-ply door should have been employed.

Advantages and disadvantages same as for 3-ply doors.

4—**Rolling Steel.** Interlocking slats or corrugated sheets (latter suitable for exterior wall openings only) running in guides and counterbalanced by springs. See page 245.

Advantages: no floor space and minimum wall space required; can be placed in door openings to protect against falling walls.

Disadvantages: high radiation; not suitable for egress; upkeep not as simple as other types of doors; higher cost.

5—**Steel Plate.** (See Fig. 33.) Plate doors not over $\frac{3}{16}$″ thick on angle iron frames, used chiefly in Chicago territory.

Advantages: corrosion protection easy; moderate cost.

Disadvantages: high radiation; floor grooved to guide lower edge, troublesome; automatic action frequently complicated.

6—**Hollow Metal.** (See Fig. 33.) Sheet steel with hollow or partly hollow stiles and with asbestos filled panels.

Advantages: best fire-resisting power of any swinging door; neat appearance.

Disadvantages: not readily made automatic; higher cost.

7—**Metalclad.** (See Fig. 33.) Thin gage metal over wooden door.

Advantages: neat appearance; relatively low cost.

Disadvantages: not readily made automatic; lowest fire-resisting powers.

8—**Counterbalanced Elevator.** Made in two sections, counterbalanced on each other; mounted in guides in elevator shaft. Tinclad, sheet metal; or steel plate construction can be employed.

Advantages: no floor space required; combines most successfully fire and accident prevention on elevator shaft, as normally closed.

Disadvantages: upkeep slightly more troublesome; higher cost.

ESSENTIAL FIRE DOOR INSTALLATION POINTS.

9. For permitted maximum door sizes see table on page 228. 80 sq. ft. is generally the limit for fire wall openings. Regular labeled doors may be secured up to 120 sq. ft. Even larger doors may be labeled to indicate proper materials, design, and workmanship, but the label does not guarantee equal fire-resisting power with the smaller doors. For swinging doors, maximum sizes in every case indicate limit of height and width where a pair of doors is used. A single door generally may only be a little more than half of the area specified.

10. Two doors, one on each side of the wall, are required for standard cut-offs, except under special conditions, as between a boiler room and engine room in a fire-resistive power station where amount of fire risk is exceedingly moderate. This point is one on which the opinion of the Underwriters having jurisdiction should be asked.

11. Two doors (commonly called double doors) are needed for the following reasons:

a—Fire doors are vitally important. The separation of buildings is entrusted to them. Even two cannot be expected to equal a good brick wall in fire-resisting power, but experience has shown that they come close to it.

b—In a severe fire, one door may be practically destroyed, but it partly protects the second, and that stops the fire.

c—The dead air space between two tightly closed doors has great fire-resisting value.

d—The possibility of fire lapping around the edges of two doors in series is slight, whereas it may spread around a single door quite readily.

12. No combustible sliding or swinging draft stopping doors should be used on fire wall openings. If draft stops must be provided they should be in the form of a partition set back safely from the fire door opening.

13. Horizontal sliding fire doors with tracks sloping ¾″ per foot, shown in Fig. 34, are advisable where head room permits. The horizontal track type of door shown in Fig. 35 should only be used when absolutely necessary. Swinging doors fitting into a rabbet in the wall are generally tighter than sliding doors as regards fire and smoke. The sliding door more readily is made automatic.

14. Single doors are used on elevator and stair well openings, because a fire to go from one floor to the other has to pass through two doors, and the effect of double door protection is secured by a single door on each floor.

APPROVED DEVICES.

15. Experience has proved time and again that the manufacture of even the simpler forms of fire doors and shutters cannot safely be entrusted to general contractors, sheet metal workers, or carpenters, let alone the average plant mechanical force. The failure of a single device at time of fire may be a matter of great moment. Labeled doors and shutters have the needed fire-resisting abilities, relieve the owner of difficulties and doubts regarding his purchases, and meet the requirements of the fire insurance interests.

16. Labeled devices cost very little more than those of unknown quality. The cost of a fire door label (including all inspection costs) is only 40c.

FIRE DOOR UPKEEP.

17. The equipment of which so much is likely to be required in case of fire must be properly maintained. Common defects include:

a—Corroded, torn, or battered metal covering. See Fig. 34 for sheet steel protection to guard against injury by trucks.

b—Dry rot in tinclad doors. This is detected by screws pulling out and edges caving in and by hammer and awl tests.

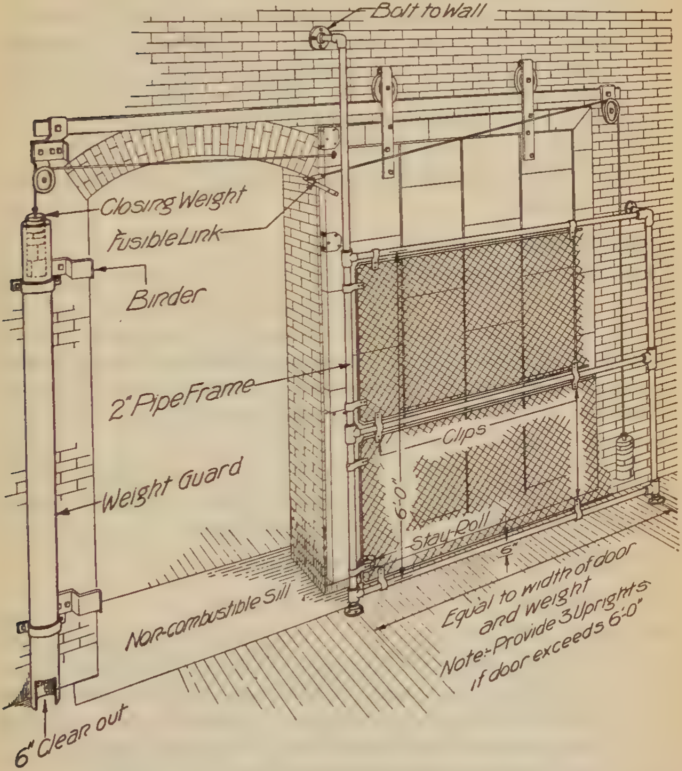


Fig. 35. Horizontal Track Automatic Fire Door with Protective Guard.

c—Vents not provided on tinclad doors (3" to 4" hole through tin on exposed side—one side only).

d—Incomplete hardware equipment and loose parts.

e—Chafing strips and their companions, bolted together through door, greatly add to the fire-resisting power of tinclad doors, and reduce cutting of tin covering. Strips are commonly omitted.

f—Jamming and sticking of doors.

g—Automatic operating mechanism not in commission.

h—Doors blocked by temporary or permanent storage. See Fig. 35 for fire door guard. Metal construction for guard is, of course, superior to wood.

i—Binders filled with blocking to make opening of doors easier.

j—Not closed nights, Sundays, and when openings are not in use.

HARDWARE.

18. Labeled hardware also is essential to safety. Standard sets of hardware, accurately cut and fitted, may be had for sliding or swinging doors and shutters. To avoid sliding doors falling from tracks, it is essential that the clearance between the track and the top of the door be less than the depth of the hanger groove. An approved form of door closer for swinging doors is now on the market.

19. Panic bolts, readily operated by pressing against them, are commonly used on swinging exterior doors through which large numbers of persons might pass.

AUTOMATIC CLOSING DEVICES.

20. National Board Rules read as follows:

a—Where the conditions are such that the spread of fire through the wall openings is likely to be very rapid, or where the spread of fire through wall openings is likely seriously to endanger life, the fire doors should be operated by an approved automatic quick-operating door closing device or system.

b—Where the conditions are such that the possibility of the very rapid spread of fire through the wall openings is small, and where the spread of fire through such openings is not likely seriously to endanger life, the fire doors may be operated by a less sensitive approved automatic door closing system or device such as the fusible link type.

Note: It should be noted that the question is not so much that of rise of temperature as of rapidity of spread, and that in all situations where a very rapidly spreading fire appears likely, the sensitive device should be used. Such situations include those where there is a liability of a train of flammable material leading through the opening, or where highly flammable material is present on each side of the opening in such close proximity to it that fire could pass through the opening before generating sufficient heat to operate the less sensitive door closing device.

21. The first requirement is met by such devices as the Derby and Lowe, described below, the second by fusible links operating at approximately 160 degrees, various methods of installing which are shown in Fig. 36. The following is a brief description of how these various methods operate.

Case A.

Ceiling link supports horizontal bar over which end of counterweight cable is looped. Fusing of either link releases door.

Case B.

Horizontal track door, closed by dropping of heavy weight, normally supported on bell crank, on to smaller weight attached to door closing cable.

Case C.

Simplest and most commonly used counterbalance scheme.

Case D.

Horizontal track door, normally balanced by weights of equal size.

Case E.

Unsatisfactory arrangement, as link passes out of door opening when door is half closed.

Case F.

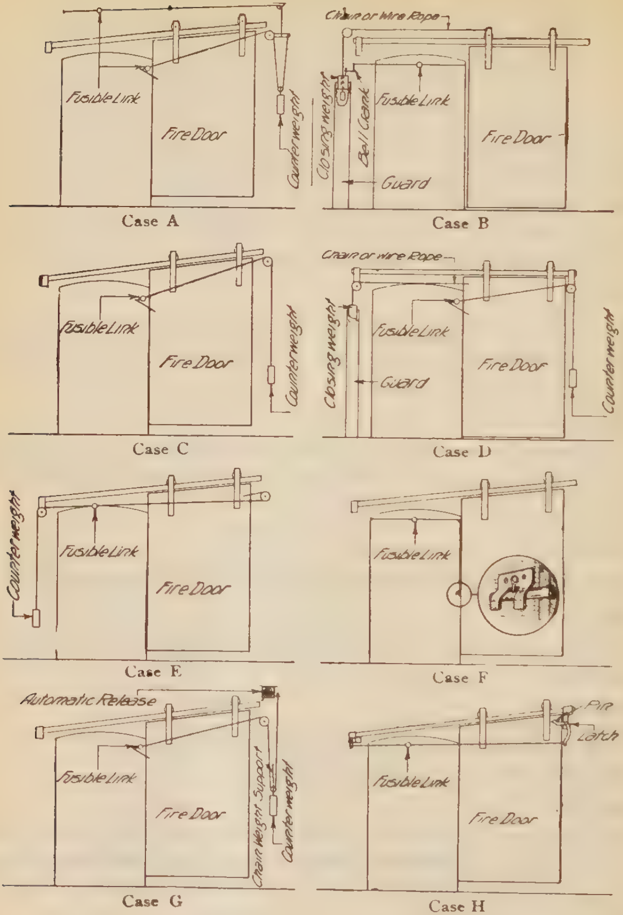
Latch released by fusible link. Door can be closed without disturbing automatic feature. Not very reliable and not always easily maintained.

Case G.

Shows application of Lowe release mechanism near ceiling. The Derby release box application may be similar.

Case H.

Another form of latch not commonly found.



Case A
Case B
Case C
Case D
Case E
Case F
Case G
Case H

Fig. 36. Automatic Closing Devices for Fire Doors.

The best practice is to use:

a—Gravity sliding rather than horizontal track doors.
b—Case C for ordinary situations, and Cases A and G where flash fire hazards exist.
c—Case D with horizontal track doors.

22. The **Derby** electric release box consists of an electro-magnet in a metal case which, through the medium of levers, holds the rope or chain which controls the fire door. Pull is limited to 50 lbs. It is simple in construction, strongly made, and should withstand hard usage. An electric circuit and heat actuated (automatic sprinklers and thermostats) or manual appliances for transmitting and controlling the current actuating the electro-magnet must, of course, be installed and maintained to provide the complete system.

23. The **Lowe** device, which is placed at the ceiling above the door, operates on the "rate of rise" principle, by the expansion of air in a metal diaphragm, and is very sensitive to heat. There is little doubt that, assuming apparatus is in operation and door properly maintained, it will operate ahead of the time that fire and probably even smoke reach the wall opening. For property protection very quick closing of fire doors is generally an advantage, and for certain situations, as on vertical openings, very quick closing of doors is a real life safeguard. The same may not, however, be true of doors through which persons would escape from the building.

24. Both the Derby and Lowe devices can be used also on horizontal sliding, swinging, vertical sliding, and rolling forms of doors, and in connection with dip tanks, blowers, dampers, engine stops, motor stops, quick opening valves, automatic skylights, theatre curtains, water curtains, and for similar purposes.

25. Upkeep points for self-closing equipment for fire doors include:

a—More readily attached to sliding than to swinging doors.
b—Not advisable on shutters exposed to the weather.
c—Where doors require closing weights, these should run in pipes or boxes to protect against material blocking their descent. Such protection is also occasion-

ally advisable on gravity sliding door weights. Weights pulling doors shut should be attached with wire cables or chain which cannot readily burn off. See Fig. 35.

d—Links on brackets projecting into door openings at height greater than man's head are superior to links on ropes that move out of the opening when doors are partly closed.

EXTERIOR WALL OPENINGS

26. Door openings in exterior walls offer no problems different from openings in interior walls, except protection against the weather. Windows, on the other hand, need special treatment, and this section is devoted to the need of, and the method of, protecting window openings.

27. Unprotected window openings are a constant menace in our cities, and also frequently in individual plants where mutual exposure exists between buildings. Windows need protection, not only against fire in other buildings, but also to prevent fire spreading from story to story through the medium of wooden window frames. To build a modern fire-resistive building, fill it full of valuable material, and leave its windows unprotected, where there is an appreciable exposure, is very much like building a massive safety deposit vault, placing large values therein, and failing to provide a door. The development later of exposure and the difficulty of providing window protection at that time must also be considered. The cost of adequate window protection over and above wooden frames, especially if plate glass is used in wooden sash, represents a very small percentage of the value of the building and its contents.

28. The careful calculation of losses sustained in fire-resistive buildings in Baltimore showed 100% loss of contents in practically every case, and an average of about 70% in building damage. Approximately the same was true in San Francisco. The burning out by exposure across an 80-ft. street of the upper seven stories of the fifteen-story Burlington Building in Chicago, on March 15, 1922, with the loss of vital records, many irreplaceable, and aggregating literally millions of dollars in value, has once more called attention to the weakness of modern buildings as regards their window openings.

HIGH VALUE DISTRICTS.

29. The need of window protection is especially great in the congested districts of our cities, where the largest area, highest buildings, are located. The reasons lie chiefly in the following facts:

a—Here exist the chief possibilities for devastating conflagrations with all of their attendant ills.

b—Fire departments are incapable of fighting from the ground fires over 6 to 7 stories high. There is literally in some of our larger cities a likelihood of a conflagration sweeping over the heads of the fire department.

c—The amount of combustible trim in the average so-called "fire-resistive" office building is astonishingly large; 5 lbs. per sq. ft. of area being perhaps an average.

d—The fuel in furniture, books and papers, rugs, etc. probably averages another 10 lbs. per sq. ft. The heat value in 15 lbs. of wood and paper is about the equivalent of about two thirds of a gallon of fuel oil.

e—This fuel is spread throughout the entire structure and generally stairs and elevators are open flues.

f—The values of contents are very great, and the records, which often represent greater values than the building and equipment, are almost always uninsured.

30. Other corrective measures are necessary beside protection against exposure, but from a conflagration standpoint that is the most important.

31. The modern tendency with office buildings, as well as with factories, to use metal sash, even with plate or thin glass, is a step in the right direction, because fires frequently communicate to the interior by the burning of the wooden window frames.

32. The table on page 225 covers three classes of exposure, namely, severe, moderate, and light, and it indicates the kinds of protective coverings approved and recommended for these situations. For protection there are available:

a—Swinging shutters of sheet metal, steel plate, and wood covered with metal.
b—Rolling shutters.
c—Wired glass windows in hollow and solid sash designs.

33. The relative ratings given the protective coverings by the authors are without regard to feasibility under certain conditions. For example, for severe exposure a sheet metal shutter alone is deemed preferable, but it is seldom feasible to protect by shutters an attractive office building. The following represents possibilities of achieving needed degrees of protection for window openings:

For Severe Exposure.

a—Metal frame wired glass windows combined with rolling, steel plate, or tinclad shutters.
b—Metal sash combined with rolling, steel plate, or tinclad shutters.
c—Wooden window frames protected with sheet metal shutters closing into rabbets in wall.

For Moderate Exposure.

d—Metal frame wired glass windows, Class E, with 720 sq. inches maximum size for glass.
e—Wooden window frames protected with sheet metal, rolling, steel plate, or tinclad shutters.

For Light Exposure.

f—Metal frame wired glass windows, Class F, with lights up to 54″ in both dimensions.

DETAILS REGARDING WIRED GLASS.

34. Wired glass in metal frames has made an excellent record for itself, so good in the cases of apparently severe exposure, and in a few instances in conflagrations, that there is much sentiment in favor of using it for protection for wall openings under all conditions.

35. While it may frequently be decided to use it alone, where the exposure is severe, trusting to good building construction, sprinkler protection, inside hose, slightly combustible contents, and other mitigating factors, it must be recognized that when such a window is really subject to serious fire assault, from without or within, it is more than likely to fail. Not infrequently in buildings in which internal fires have raged, the drafts have been such that doors or windows in the structure itself, or in exposed ones, have apparently been bathed in flame, but in reality very slightly exposed.

36. Approval has been extended to several makes of wired glass and to scores of factories making hollow metal sash in stationary, double hung, single and double pivoted, casement, and other forms. More recently, equal approval has also been granted to several makes of solid sash, the fundamental difference between approved sash and ordinary factory sash being that each pane of wired glass is held by continuous fillet angles on all four sides. Clips and putty ordinarily used will not withstand a severe fire test.

37. Not only is it advisable to purchase only labeled sash and approved glass, but it is vitally necessary, if glazing is done at the building where the windows are to be installed, as is usual, to see that this glazing is properly done. A few cases have been found where ⅛″ wired glass, designed to be used where ordinary glass would be likely to be broken and unsuitable for fire-protection purposes, was used in fire windows.

38. When fire occurs inside of a building, the heat may be sufficient to melt the glass on the floor on which the fire has broken out, but the likelihood is that the wired glass on the floor above will not fail, and that because of this fire will be prevented from spreading upward by means of exterior wall openings.

39. Inflammable contents naturally should not be placed close to windows where there is danger of exposure, a minimum distance of 3 ft. being the usual practice.

40. Wired glass is also of much value in the protection of floor openings, as for door and partition work where light is essential. Wired glass is commonly used in heavy metal frames around stairways in hotels, department stores, and in many other types of buildings, and while such protection cannot be considered the equivalent of a standard partition, it nevertheless has great value in places where better protection is not feasible. See Fig. 30, page 204.

41. Wired glass is commonly being required as protection to persons on fire escapes, where such escapes pass window openings.

42. Wired glass comes in a variety of forms, polished plate, rough, figured, ribbed, and in special prism designs to improve lighting away from window openings and to reduce glare.

43. A recent development in the manufacture of wired glass is that of producing corrugated sheets of the standard one fourth inch thickness and with corrugations designed to fit the standard sizes of corrugations of iron and asbestos. This permits the inserts of sheets of wired glass in roofs or walls with minimum installation expense.

44 Another recent development in the manufacture of glass, both with and without wire, is " Actinic " glass. It is of a slightly amber tint and, according to government tests, has the properties of intercepting a large percentage of the heat (infra-red) rays and of the glare (ultra-violet) rays of the sun, thus reducing eye strain and also to a minimum the fading of colors.

45. Wired glass can also be secured with especially grooved or corrugated surface designed to hold water of condensation, and to carry it off to the lower edge of sheet where the condensation can dc disposed of and objectionable dripping avoided.

WIRED GLASS VS. TINCLAD SHUTTERS.

46. It is natural to compare wired glass windows with standard tinclad shutters as protection against exposure fires, and the fire records would tend to prove that the many advantages of the former far offset the disadvantages. While it is true that glass will melt at temperatures known to occur in ordinary fire (glass softens at about 1500° F. when subject to heat from one side), and while it is also true that wired glass radiates heat to such an extent that combustible material may be ignited on the side away from the fire, nevertheless both these features have been shown to be of relatively little importance in actual practice. To a not inconsiderable extent, this is due to the fact that the wired glass windows are an integral part of the building and are well maintained and normally closed, whereas fire shutters commonly are installed to bring about insurance rate reductions, and very commonly are improperly maintained, let alone regularly closed at the end of the working day.

47. An obvious advantage of wired glass windows over shutters is the fact that they are not unsightly and can be used on all exterior openings except show windows. Also, wired glass is transparent or translucent, and fire within may be seen from the outside. The rather serious objection to metal fire windows, namely, that it was difficult to make them tight, has now apparently been overcome by certain makers.

SOLID STEEL VS. HOLLOW METAL SASH.

48. The question of the relative merits of hollow sash vs. the modern solid sash factory type of windows not infrequently rises, and the following can be presented as the advantages:

a—Very large percentage of light area.
b—Moderate cost.
c—Mechanical operation possible.

49. Among the disadvantages are:

a—Inability to escape through windows.
b—Difficult for fire department to enter through windows.
c—Difficulty in cleaning.
d—Difficulty in providing shades or awnings.

50. Speaking generally, a building should not depend upon its windows for exit purposes, and, from a fire-resisting standpoint, either type of construction with sash approved and glass properly installed is satisfactory.

ROLLING SHUTTERS.

51. The essential facts from a fire wall standpoint regarding rolling shutters will be found on page 232. From the standpoint of protection of exterior wall openings, the more recent developments in the use of shutters warrant special treatment.

52. There is little question that for severe exposure the ideal treatment for buildings where appearances count is the combination of the automatic rolling shutter and either a metal frame wired glass window or metal sash, incombustible in itself. The same thing would be true of other buildings, but costs probably would be deemed prohibitive except perhaps on principal street fronts. Rolling shutter areas up to 100 sq. ft. are approved for exterior wall opening duty.

53. Rolling shutters on the outside face of the wall, particularly older installations, have given up-keep troubles, and have had the particular objection of being incapable of test without skilled mechanics and occasionally life jeopardy.

54. The more recently developed shutters, on the other hand, whether placed on the face of the building or concealed in the wall opening, can be tested from the inside of the building and reset from the same point. Shutters, furthermore, have a sufficient amount of counterbalancing spring so that they do not close violently and so that they can be raised without undue effort.

55. Rolling shutters unquestionably fit more tightly into their grooves than the average swinging shutter does either against the face of a wall or into a rabbet.

CHAPTER 16

BUILDING CODES

1. With the increasing realization of the direct bearing on life and property loss of poor building construction, more and more cities of the country have put building codes into effect. Many have materially improved their codes in the light of local experiences or because of the trend of the time calling for better construction and more careful supervision.

2. A building code applicable to a whole city must, of necessity, permit conditions far below the very best practices, and the organization that wants a superior building ordinarily uses the building code as a foundation on which to build, and easily meets the legal requirements in the course of its planning.

3. The most notable step in furthering the adoption of good building codes was the preparation in 1905 of the first Model Building Code by the National Board of Fire Underwriters. In 1920 the Fourth Edition was issued. The code is in form for adoption by City Councils, and contains valuable illustrations and tables as well as carefully drawn rules covering all types of structures, forms of construction, and legal control. The code should be consulted by every designing and fire protection engineer.

4. The National Board of Fire Underwriters has also prepared suggested Ordinances for Small Municipalities which covers just what such communities need in the way of building regulations and the control of hazards.

5. To further the construction of dwellings in particular, and at the lowest cost consistent with safety and efficiency, a building code committee was appointed by the U. S. Department of Commerce. This committee made its first report on a dwelling code in 1922; this code and any subsequent publications of this committee warrant careful study.

CHAPTER 17

DEPARTMENT STORES

1. The modern department store presents a problem of unusual importance and interest to the fire protection engineer. Buildings oven ten stories in height are fairly common; some of the older stores have unbroken areas of an entire city block (up to 100,000 sq. ft.); open elevators and stair wells and especially unprotected light wells make rapid upward spread of fire and smoke almost certain; large quantities of highly inflammable goods are so distributed that fire can spread over them rapidly; and the population of the stores in clerks and shoppers reaches figures well in excess of 10,000 at one time. The possibilities of life loss by fire are undoubtedly greater in some of the older large department stores than in any other class of building.

2. The only reason that the country has not experienced a tremendous holocaust in a department store is that the management of these stores in almost every case has a keen sense of its responsibility, aims to maintain good conditions, and has installed automatic sprinklers throughout the premises. In one especially poorly built department store of large size a small electric fire broke out during the Christmas rush, on a day when 50,000 customers entered the building. The management was so fearful of a recurrence that it rewired the building at a cost of approximately $100,000.

3. The report of the Committee on Safety to Life of the N. F. P. A. approved in 1921 covers in detail construction, height, areas, protection of vertical openings, sprinklers, and particularly the exit capacity required under differing conditions of construction and protection. Actual counts in representative department stores during the Christmas and Easter rush periods showed the advisability of basing exits on the assumption that population under rush conditions would be one person (customers and employees) for the following gross building areas:

	Sq. ft. per person
a—Street floor	15
b—Floors above street floor	50
c—Sales basements	20
d—Basements not used for sales	100

4. Some of the features that need particular attention to create as good as possible fire conditions include:

a—Superlatively good housekeeping, with prompt and safe disposition of all refuse and sweepings.

b—Particular attention paid to kitchen, tailoring shop, upholstering shop, packing departments, and similar points of danger.

c—Absolute prohibition of smoking on the part of customers as well as of employees.

d—Protection of vertical openings in manner set forth in Chapter 13. Light wells should, by all means, be floored over, and ventilation be secured artificially if necessary. An open light well invites panic more than any other structural defect.

e—Provision of one or more fire walls, continuous from lowest floor to roof, to afford means of horizontal egress.

f—Provision of liberal capacity stairs or other means of egress, and the prominent marking of these.

g—A fire alarm signal system of the kind that will not alarm the customers, but will call the public fire department and notify the private brigade.

h—A highly trained fire brigade.

i—Frequent fire drills to train employees not only to leave the building in a prompt and orderly manner, but to direct and assist customers to do the same thing. Customers cannot be drilled. Panic is particularly to be feared, especially as customers are largely women.

j—Complete fire fighting equipment, including automatic sprinklers, standpipe service, and hand extinguishing apparatus.

k—Continuous supervision of all fire conditions by a competent man or men specially assigned to this work.

5. The management of a department store cannot afford to overlook any reasonable structural, protective, or management steps that will safeguard life and property for which it is responsible.

CHAPTER 18

DWELLINGS

1. More lives are lost by fire in dwellings, apartment houses, tenements, and hotels in the course of a year than in all the factory, school, theater, and similar holocausts in the average decade. The latter class of fire, because of its greater magnitude, receives extensive publicity, the former comparatively little, and the public fails to realize that the record of our country proves that fire prevention, like charity, should begin at home. The best data available indicate that of all lives lost by fire approximately 60% are children, and 20% each adult women and men.

2. Not only the direct result of home fire prevention is vitally important, but the educational effect on the children of this generation will be reflected in the fire loss in what might be termed "public fires" in the coming decades.

3. If a special effort were made to design the most combustible type of structure, it would be difficult to exceed the conditions in the average dwelling. Wooden walls (brick or stone walls add little to the fire safety), wooden floors, wooden roofs, wooden doors and trim, open wooden stairs, unstopped vertical flues in partitions, and highly inflammable contents is the usual situation. Given such construction and numerous possibilities of fire, not recognized or disregarded, it is no wonder that dwellings and allied structures are responsible for much of our life and property loss.

4. While the possibility of rapid fire spread and life jeopardy, especially at night, does exist in almost all homes, the very fact that conditions are under the control of the family makes a high degree of fire prevention possible. The excellent pamphlet, "Dwelling House Hazards," prepared by the National Board of Fire Underwriters, should be secured and studied by every man who desires to safeguard against fire his own family or others for which he may be responsible.

5. This also applies to the 1922 Dwelling Code promulgated by the Building Code Committee of the U. S. Department of Commerce and for the 1922 specifications for Private Residences of the N. F. P. A.

CAUSES OF FIRE.

6. Special reference is made to the following sections in Chapter 7, Common Fire Causes:

7. Lighting—Sunlight; electricity; city, gasolene, and acetylene gas; lamps; lanterns.

8. Heating—Chimneys and flues; coal and wood stoves; steam and hot water heating; fireplaces; hot air furnaces; ashes; gas, gasolene, alcohol, and kerosene stoves; pressing irons; electrical devices.

9. Miscellaneous—Metal polish; spontaneous combustion; matches; lightning.

10. The three principal causes of fire in city dwellings undoubtedly are:

a—Matches.
b—Refuse.
c—Heating apparatus.

In the country, lightning is also a serious hazard.

11. Matches—To use other than safety matches (striking only on the box) in a home where there are small children is to invite disaster. Almost daily reports of children being burned to death by matches are carried by the daily papers. Burnt matches furthermore belong in metal containers and not in waste baskets.

12. Cleanliness—Poor cleanliness is a direct cause of fire. Spontaneous combustion in oily rags, mops, and dust cloths, in burlap, and even in straw or hay is always a possibility, but the objection to poor cleanliness comes chiefly from the fact that a carelessly discarded match or cigarette butt, a flying match head, a drop of hot soot from a gas burner, an electric arc, or heat from a stove or furnace may ignite combustible material and start a serious fire. A match discarded on a cement basement floor constitutes little hazard, but if thrown into a barrel of packing material the danger is great. Immaculate cleanliness in basements, attics, closets, garages, barns, and sheds is advisable, and even straw banked around houses and shrubs is dangerous. The disposal of needless combustible material, such as empty boxes, barrels, crates, and broken furniture is next in importance to a high degree of cleanliness. Particularly should excelsior and straw be disposed of at once, even if there is a likelihood that it may be useful at some future date. Fifteen cents worth of excelsior has burned many a home.

13. Heating apparatus, as indicated in the list of topics above, is extensive and varied in the ordinary home. It must be remembered that here are definite hazards tolerable only if under control. It is not too much to ask that periodic examination, especially in the Fall, be made by the head of the house, and by the property manager or agent in charge of apartments, hotels, clubs, and theaters, of all such equipment with a view to correcting defects. Chimney and fireplace brickwork, smoke and stove pipes, floors under devices, gas pipes and valves, electric wiring, etc., should come in for careful review and for cleaning and repairs where necessary. The importance of the subject warrants calling in a competent man to do this work if the owner does not feel qualified.

14. Heating hazard practices that warrant special condemnation include:

a—Starting fires with kerosene and even with gasolene.
b—Placing kindling in oven.
c—Overfilling fire pots.
d—Drying clothing over stoves or on hot pipes.
e—Leaving electric irons with current on.
f—Using electric bedwarmers.

15. Lighting danger points, other than those covered in Chapter 7, include:

a—Danger of amateur electrical work. A power house and not a set of dry cells is behind a lighting system. Only competent electricians should be allowed to work on circuits.
b—A supply of properly sized fuses should be on hand and circuits should not be over-fused. The fuse is to an electric circuit what the safety valve is to a boiler.
c—Paper and fabric shades on lamps have caused many

fires. Wrapping an electric lamp in a towel or blanket to use as a foot-warmer is almost certain to cause a fire.

d—Long extension cords, tied aside, looped over fixtures, and even secured with nails and staples are decidedly dangerous.

e—Electric devices such as vacuum cleaners and heaters often require more current than lighting wiring can safely carry, and warrant the installation of special circuits. Any device taking over 10 amperes should not be connected to ordinary lighting circuits.

f—Glass bowl lamps are more dangerous than metal ones, and hanging a lamp over a table is safer than placing it on the tablecloth. Many a fire has been caused by a child or dog pulling over a lamp.

g—Candles have little place in a home except for decorative purposes. The electric flashlight is more convenient and far safer.

SPREAD OF FIRE.

16. Fire-resistive Construction—The percentage of dwellings that are of fire-resistive construction is negligible, and yet progress is being made, notably in very pretentious homes and in houses for workmen. Concrete, gypsum, and tile lend themselves to dwelling construction, and it is likely that increasingly rigorous building ordinances, the increasing cost of wood, and the increasing number of and skill of contractors who can build this type of structure will stimulate the building of houses structurally on a par with modern factory construction.

17. Metal Lath and Plaster Construction. The remarkable ability of metal lath and plaster to protect wooden studs and joists, as demonstrated by tests of Underwriters' Laboratories (see page 208, par. 26) indicates that it is possible to all intents and purposes to build a remarkably safe dwelling by the use of metal lath and plaster for ceilings, partitions, and walls even where the building is entirely of wood. While metal lath and plaster properly applied can withstand serious fire for an hour or more, wood lath and lime plaster fail in a very few minutes.

18. Improvements in existing houses to prevent the spread of fire can take the form of:

a—Stopping of flues in studding (especially at basement ceiling and at attic floor) for a height of at least 3″ with cement plaster, mineral wool, or substantial plank.

b—Applying metal lath and plaster over heating plant, smoke pipe, and fuel storage, and preferably over entire basement ceiling.

c—Providing doors at tops or bottoms of stair flights, occasionally with springs or doorchecks to keep them normally closed.

d—Replacing ordinary glass door panels and transoms with wired glass, held by metal or metal covered angles or fillets.

e—Replacing combustible roof coverings. See Chapter 14. The new asphalt shingles weigh about the same as wooden ones, and can be used without overloading roof structures.

EXTINGUISHMENT OF FIRE.

19. For the want of a convenient pail of water many a home has been burned. Pails of water can be kept without objection on account of unsightliness in basements, attics, and storerooms. The average dwelling, however, is warranted in owning a fire extinguisher. The choice lies between:

a—A 2½ gallon net capacity, soda-acid extinguisher.

b—A 1½ gallon net capacity, soda-acid extinguisher.

c—A one quart carbon tetrachloride extinguisher.

20. The order indicates the relative desirability, except that, where the weight of the 2½ gallon machine (about 38 lbs. when filled) is too great for handling by women and children, one or two of the smaller soda-acid extinguishers can be used. Water, which the soda-acid extinguishers discharge, is a better extinguishing agent for dwelling fires than carbon tetrachloride. The family must know how to use extinguishers. Explanations are not as good as demonstrations.

21. Grease fires generally yield better to sand, earth, ashes, salt, soda, or even flour than to water.

22. A garden hose is a very effective extinguisher if the pressure is good and if the hose is readily available.

23. Automatic sprinklers, fed by city water where supply is good, will insure against any serious basement fire.

24. Thermostats to give prompt notification of fires are especially valuable in event of a night fire. While entire dwellings can be protected, the need is greatest in basements, kitchens, laundries, attached garages, and closets and store rooms.

25. Establishing the location of the nearest fire alarm box, finding out where the key is if one is needed, and making certain that the members of the family know how to operate the box is desirable. While the telephone is quicker, and should be used in addition to a city fire alarm box, the latter eliminates misunderstandings and generally brings more apparatus.

EGRESS.

26. In every building in which people sleep it is especially important that the occupants know the available means of escape. Chapter 36 will bear reading in this connection. Items of special interest to homes include:

a—Porches make excellent places of temporary refuge.
b—Ladders kept on porch roofs, secured by chains so that they will not be lost when slid over the edge, insure a means of escape independent of outside assistance.
c—Connecting doors between rooms, giving access to a porch without going into halls, are valuable.
d—A portable ladder in the barn, garage, or under the porch, may make escape from windows possible.
e—Individual room escapes, as described on page 653, are often advisable, especially in rooms above the second floor.
f—An alarm system, powerful enough to be heard by all persons, and operated by push buttons in each hall, in certain rooms, and on the outside, is always warranted in a more pretentious home. This may be combined with a thermostat system.

CHAPTER 19

GARAGES

1. The fire record of garages, both public and private, has been bad. The inherent hazard of gasolene is largely responsible for this. Methods by which it has been ignited include matches, forges and furnaces, torches, heaters, back firing, static electricity, electric arcs (including breaking of incandescent lamps), gas burning devices, acetylene lights on cars, burning out of cylinder carbon, and spontaneous combustion of waste. 48% of the fires recorded by the National Fire Protection Association are of gasolene origin outside of the car and a large proportion of the 19% attributed to the automobiles themselves were also of a gasolene character.

2. While the fire record of filling and service stations is believed to be better than that of garages, the same precautions set forth herein are warranted in such stations in so far as they apply.

3. Storage and Handling of Gasolene—The most important feature is the proper storage and handling of gasolene. Storage tanks should be outside and underground; inside discharge systems operated either by pump or by means of water pressure; inside connections preferably in a separate cut-off ventilated room; and the handling of gasolene to be through means of hose, pump tanks on wheels, or safety cans. Open containers of gasolene are ultra-hazardous. See Chapter 7.

4. Static electricity may be produced by gasolene flowing through a rubber hose or from a metal can, especially if wood covered. Fires due to static electricity have been fairly common, and loss of life has occasionally taken place. The remedy is to run a bare stranded copper wire through the inside of a rubber hose, making it mechanically and electrically secure at the pump and at the nozzle, and to bring hose nozzles and cans into direct metallic contact with the funnel or the car fill opening. See also page 41.

5. Smoking—Rigorous enforcement of the "No Smoking" rule is absolutely necessary if safety from fire is to result. See Fig. 20, page 112.

6. Boiler rooms should be cut off and, if in basement, should have solid ceilings and be entered from the outside. Steam or hot water heating only is advisable, especially for large garages. Private garages often are heated by steam or hot water lines run from the residence, and special types of coal burning or gas burning safety heaters, which have been designed to meet the small garage situation, probably give a considerable measure of protection, where properly installed and maintained.

7. The use of an air-cooled automobile, or of non-freezing mixtures in radiators, obviates the need of heat except possibly in the very coldest climates.

8. Pits—Owing to the weight of gasolene vapors, all depressions in floors should be avoided. Mechanical ventilation for large pits is often necessary.

9. Sewer connections require traps or separators to prevent possible fire spread through them in either direction. See Fig. 18, page 101.

10. Cleaning of cars and metal parts should not be carried on with gasolene. Kerosene is recommended for this purpose.

11. Repairs, except minor ones, should be made in a detached shop. No repairs requiring fire heat should be carried on in main garage. Electric soldering irons, however, are not objectionable.

12. Lighting should preferably be by electricity, although gas arcs, equipped with pilot lights and located 10 ft. or higher from the floor, have proved safe. The approval of the Underwriters having jurisdiction must, however, be secured before gas lighting is installed. Conduit wiring with fuses and switches, preferably located where no gasolene vapors may be present, is standard practice. The hazard of key sockets on extension cords, and of breaking incandescent lamps, is so great that exceptional care is needed. Cords should plug into outlets 4 ft. to 5 ft. above the floor, should be of heavy reinforced portable type, well maintained, sockets should be keyless, and lamps should preferably be enclosed in heavy rod guards to insure them against breakage. See Fig. 4, page 39.

SPREAD OF FIRE.

13. Construction—For garages housing a large number of cars, and especially if over one story high, the only proper construction is fire-resistive. This is generally the requirement of building codes. The intensity of fires in automobiles has been demonstrated in a number of buildings of fire-resistive construction, as well as in thousands of a combustible character. The gasolene, oil, wood, upholstery, rubber tires, and top portions of an automobile make a considerable aggregate in any single car, let alone in dozens or scores.

14. The tendency to build even private garages entirely or partly fire-resistive is commendable. The use of metal lath and plaster will give a high degree of fire-resistance and is particularly advisable for old buildings converted into garages.

15. Vertical Openings—The protection of vertical openings is particularly important in large garages, because through the medium of gasolene in liquid or vapor form fire can spread downward as well as in the usual upward manner.

EXTINGUISHMENT OF FIRE.

16. The large garage, especially if not of fire-resistive construction and having moderate floor areas, can to great advantage be equipped with automatic sprinklers.

17. Inside hose, soda-acid extinguishers, sand pails, and carbon tetrachloride extinguishers, both on cars and in garages, all have their place in large garages, and hand extinguishment belongs in every private garage, even if limited to a carbon tetrachloride extinguisher on the motor car and to a soda-acid one in the building.

CHAPTER 20

HOTELS

RESORT HOTELS.

1. The fire record of hotels of the seasonal or resort type has been notoriously bad. These structures, often of great size, generally entirely of wood, without the semblance of a fire stop either horizontally or vertically, often without even detached kitchens and laundries, and without adequate inside or outside fire fighting protection, have, in practically every case, been total losses if a fire got beyond the incipient stage.

2. The freedom from holocausts in resort hotel fires can be attributed largely to good fortune.

3. Where such properties are prosperous, there is no reason why material improvement cannot be secured through the control of causes of fire, the stopping of vertical openings, and particularly the installation of automatic sprinklers. Such protection has been installed in a number of resort hotels, and found to be desirable from a business as well as from a protection standpoint. The cost of sprinkler protection per guest per day is negligible, and the effect on his life safety great.

4. The fire protection problem of the resort hotel does not appreciably differ from that of other properties. Attention is necessary to:

a—Eliminating causes of fire. See Chapter 7.

b—Retarding the spread of fire. See Chapter 10.

c—Providing for the extinguishment of fire. See Chapters 26 to 29 inclusive.

d—Providing means for safe egress. See Chapter 36.

e—Providing alarm facilities. See Chapter 35.

5. Features of special interest in furthering fire safety in hotels of this type include:

a—Superior cleanliness, especially in basements of buildings in which persons sleep.

b—Segregation of kitchen, laundry, repair shop, boiler, and similar hazards.

c—Protection with sprinklers of these hazardous sections where not detached.

d—Adoption of a policy of gradual sprinkler protection, beginning with the basement and working upward.

e—Superior watchman service, especially during the night.

f—Posting of plans in each room to show guests the location of all available exits.

g—Provision of individual room escapes on third floors and above.

CITY HOTELS.

6. The fire frequency in city hotels has probably been quite as great as in resort ones, but the public fire department protection and better average construction have made the fire record less bad. The life loss record in city hotels, clubs, and lodging houses, on the other hand, has been much worse.

7. Modern requirements in practically all cities call for fire-resistive construction of hotels and similar buildings, and the number of superior structures which have been erected since about 1900 is gratifyingly large. Many fires in hotels of fire-resistive construction have demonstrated the great value of such construction.

8. The best buildings are practically free from any combustible material in their construction. Carpets are laid directly on cement, doors to corridors are of metal, transoms properly are omitted, elevators and stairs are enclosed, window frames are of metal with wired glass where exposure exists, standpipes, extinguishers, and alarm facilities are provided, hazardous sections are sprinklered, and effective fire fighting organizations exist among the employees. A fire in such a building is generally confined to the room in which it originates. These things pay in guaranteeing against interruption of business, loss of patronage, and in lower insurance costs and maintenance charges.

9. Where the construction is not fire-resistive, the best remedy is to install a complete system of automatic sprinklers.

10. See also specific items under Resort Hotels.

CHAPTER 21

OFFICE BUILDINGS.

1. The fire problem of the office building resembles that of the city hotel, with the important difference that people do not sleep in the former.

2. The holocaust possibilities in large office buildings are second only to those in large department stores. Over 5,000 persons are housed above the street floor in a number of office buildings in our larger cities. While the newest buildings generally have the stairs, elevators, and other vertical openings protected, many of the largest and most popular structures have nothing even resembling a horizontal fire stop from the basement, or even from sub-basements, to the roof.

3. The possibility of fire of any size being developed lies particularly in the retail stores, frequently with large stocks of combustible goods, located generally on grade floor, and often separated from the main halls only by partitions containing large areas of plate glass. Another danger lies in large unbroken areas occupied by bigger corporations, where the combustible aggregate of furniture, paper, and supplies is considerable. The amount of combustible material in wooden floors, baseboards, doors, windows, etc., will probably average around 5 lbs. per sq. ft. The furniture, paper, books, and other contents seldom weigh less than 10 lbs. per sq. ft. The aggregate of fuel in a large building is enormous. Even a small fire can produce a large volume of smoke, and how effective a chimney is a high, open elevator shaft is a matter of common knowledge.

4. The normal vertical travel in office buildings is almost entirely on the elevators, the stairs have limited capacity, their location is frequently unknown, and the physical strain of traveling down perhaps twenty to thirty flights of stairs makes them a limited and slow means of escape. Under these conditions, the possibility of disaster becomes clear. Great loss of life not only may follow a fire of considerable size, but asphyxiation by smoke and death by panic crushes and by persons falling from wall openings must be taken into account.

5. The counts, conducted for the committee on Safety to Life of the N. F. P. A. of actual occupants in a large number of representative office buildings indicates that there is one person for each 100 to 125 sq. ft. of gross floor area at the most congested time of the day. Upon this basis exit capacity must be provided.

6. Nothing resembling an effective fire drill has ever been worked out, much less put into effect, for a large office building containing hundreds of tenants over whose employees and visitors no practical control is feasible.

7. Not only the best construction in the future, but the correction of structural defects, notably vertical openings, in older fire-resistive buildings is warranted. Higher combustible structures should have sprinkler protection throughout, or at least in the more hazardous portions.

8. See the N. F. P. A. recommendations for the construction of office buildings of various classes.

CHAPTER 22

SCHOOLS

1. The safety of our children in our schools has been extensively discussed, notably because of the Collinwood disaster in Cleveland in 1908, when 172 children and teachers perished; but little, on the whole, has been done to safeguard life and property against fire in school buildings. Not even the fundamental safeguards of good cleanliness in basements, safe heating apparatus, adequate exits, and reasonable provision of fire fighting equipment have received attention in a large percentage of our schools, even in the larger cities. There have, however, been notable examples on the part of universities, colleges, and public schools of wisely conceived and liberally carried out policies of construction, protection, and maintenance, and the new construction tendency is on the whole toward better buildings.

2. The relatively small life loss in day schools has been due to the generally good fire drill systems in vogue, to alarms, and to the fact that practically all portions of buildings are occupied while the children are in them, so that prompt discovery of fire is assured. How narrow the escape from disaster may be was evidenced recently in an eastern city when only the good judgment of the principal deflected half of 700 children from their usual egress stairs, at the foot of which fire had taken hold, to the other stairs and to safety. The building was gutted in twenty-five minutes.

3. Proper school construction has received much study, and an excellent illustrated treatise on the subject is to be found in the 1916 Proceedings of the National Fire Protection Association. An illustrated article " Fire Protection for Schools " in the July, 1919, Quarterly of the N. F. P. A., and available in pamphlet form, is the most condensed, useful treatise so far produced on this subject. The causes, life loss, property loss, prevention and protection measures, and egress are covered.

4. The N. F. P. A. approved in 1922 the report on Schools submitted by the Safety to Life Committee. High points in this report are:

a—Fire-resistive construction required in new buildings of 3 stories or higher.

b—Population for which exits must be provided shall be determined.

    (1) Auditoriums and gymnasiums 6 sq. ft per person.

    (2) Other educational areas, 40 sq. ft. of gross building area per person.

c—Stairs adequate to empty any building in 3 min. at a rate of discharge of 45 persons per minute past a given point. In non-fire-resistive buildings the largest stair is disregarded in figuring exit time.

d—For existing buildings not up to standard, greater safety is proposed through the use of sprinklers and metal lath and plaster finish.

5. Wide aisles in rooms, broad halls, wide and easy stairs, and doors that swing out are fundamental safety requirements.

6. The protection of vertical openings, expensive though it may be, is generally advisable for any schools that are not under sprinkler protection.

7. Sprinklers, especially in basements, are particularly valuable in schools. A gradual sprinkler installation policy, beginning with the basements on city supply only, has been adopted in a number of cities. Greater safety results from basement installations in four schools than from a complete installation in one of three-stories-and-basement height.

8. An effective alarm system to permit of fire drills, and preferably a main line city alarm box at the front entrance, are advisable. Also, especially for larger schools in which evening classes are held, a watchman with clock is recommended. The failure promptly to notify the public fire department has been claimed to have been an important factor in several disasters in which lives were lost.

9. The one-story, without basement, type of school building is employed in Rochester and in a few other cities. It is particularly good from a fire standpoint. Each room has at least one door and one window in an outside wall, and all that is necessary to empty the school is for each class to walk out of its particular door to safety. The character of construction is, from a life safety standpoint of practically no importance. Rochester found that for equal pupil capacity, and taking into account fairly expensive real estate, the one-story school of substantial construction was cheaper than a fire-resistive structure of the ordinary height.

10. For safeguarding of hazards, structural improvements, and extinguishing apparatus, the reader is referred to chapters on the subjects on which information is desired. Special attention is called to Chapter 36 on Egress.

11. The National Fire Protection Association pamphlet on "Suggestions for the Organization and Execution of Fire Drills" contains some special suggestions applying to schools.

CHAPTER 23

HOSPITALS AND INSTITUTIONS

1. Over a million sick, crippled, aged, blind, insane, orphaned, and otherwise unfortunate or defective persons are ordinarily found in some ten thousand institutions in our country. This is the opening sentence of an illustrated, comprehensive treatise of the fire protection problem of hospitals, asylums, and similar institutions, appearing in the April, 1920, Quarterly of the N. F. P. A. The very helplessness of many of the inmates makes fire prevention the more important, and, speaking generally, the degree of care exercised by institutional managements leaves much to be desired.

2. The vital and generally least expensive improvement lies in the field of preventing fire outbreak. See Chap. 7.

3. Retarding the spread of fire is especially important where occupants cannot readily escape. See Chap. 10 and 13 in particular. The use of incombustible finish such as metal lath and plaster is exceedingly worth while.

4. Automatic sprinklers will make virtually safe even the poorest building. Partial installations, in basements and especially hazardous places, are exceedingly valuable. Adequate hand extinguishing apparatus, a local alarm system, a special city fire alarm box, employees drilled in fire fighting and in the removal of occupants, and rigorous inspection of building and equipment are essentials.

5. Of all types of buildings, hospitals and institutions where persons are helpless or confined require the best fire prevention conditions; generally these are exceedingly bad as regards construction, exits, and fire protection.

CHAPTER 24

THEATERS AND OTHER PLACES OF PUBLIC ASSEMBLY

1. Theaters used for theatrical and operatic performances and for showing motion pictures are covered in detail in the National Board Building Code and in the N. F. P. A. Committee reports. The construction requirements in most cities now are high as regards the structure and the exits. The Iroquois disaster in Chicago in 1903, in which 600 persons lost their lives in a new and structurally excellent building, markedly stimulated fire protection for theaters. The deadly inward opening door is largely a thing of the past.

2. The Boyertown disaster in 1908, in which about 200 persons perished, illustrated the life loss possibilities in a distinctly inferior structure with kerosene footlights and inadequate exits. The same thing was demonstrated in the Cleveland, S. C., disaster of 1923, where some 75 persons perished. A number of fires accompanied by life loss have taken place in motion picture houses.

3. Most fires occur on the stage or underneath it, owing to scenery and other inflammable contents spread rapidly, and smoke and gases spread to the auditorium through the proscenium arch, unless liberal ventilators are provided above the stage. The National Board Building Code calls for a ventilator area at least 10% that of the stage and for both automatic and manual opening facilities for these ventilators.

4. The auditorium should be separated from the stage by a fire wall, as free from openings as possible, with doors protected with standard fire doors, and with the proscenium arch covered by a fire curtain. Rigid steel and asbestos curtains capable of resisting considerable fire are described and illustrated in the National Board Building Code. Asbestos curtains, often necessary in smaller and older theaters, have some value. The 1907 Proceedings of the National Fire Protection Association describe their construction.

5. For new places of public assembly seating over 300 persons, fire-resistive construction is specified; for smaller houses one-story high, ordinary construction is acceptible provided wood is protected with metal lath and plaster. No place of public assembly should be planned without reference to local regulations.

6. Automatic sprinklers on the stage, under it, in dressing rooms, workrooms, etc., are rapidly becoming standard practice.

7. Ample exits, unlocked, straight, and free from stumbling dangers are fundamentally needed. The National Board Building Code specifies 1 ft. of combined width of exits (including stairs) for each tier for each twenty persons accommodated in that tier. The main entrance should have a capacity of at least 50% of the total exit width requirements for the various parts of the building.

8. For motion picture houses, the chief special provision is for a fire-resistive booth for projecting machines, vented to the outside air. For a sheet metal booth, where that is permitted, see page 110.

CHAPTER 25

PUBLIC FIRE DEPARTMENTS

And High Pressure Systems

By ENGINEERS OF THE NATIONAL BOARD OF FIRE UNDERWRITERS

1. INTRODUCTORY—As space does not permit of any extensive account of American fire department methods, this discussion will be confined to a few salient features and to pointing out the direction which experience has shown as desirable in making improvements, rather than to attempt an account of the management and operation of existing departments. It is doubtful whether the department of any one city can be used in all respects as a model for another on account of the many different conditions met. Fire departments range from the immense full-paid organizations of great cities down to the small volunteer companies of villages or factories, with almost every conceivable combination of full-paid, part-paid, call men and volunteers.

2. Until recent years no attempt has been made to lay down rules or devise methods for regulating the growth of our rapidly expanding fire departments. Each municipality has gone ahead with little regard to outside experience and made additions as the exigencies of local politics or the agitation following bad fires have demanded. When in time the growth of a city has necessitated full-paid departments the companies are forced to occupy cramped quarters originally intended for volunteer clubhouses, and to use antiquated and incomplete equipment. Some cities of 60,000 to 80,000 population are today struggling along with inadequate and inefficient volunteer departments, delaying to change to the far more satisfactory full-paid basis, either because of the political influence of the large body of volunteers or because of the apparent great discrepancy of maintenance between the 50 cents and 1 dollar per capita required by the volunteers and the $2.50 to $5.00 per capita necessary for a full-paid department. This discrepancy is only apparent, for when we consider the loss of time of the volunteers from their regular vocations, the not inconsiderable sums that volunteer organizations must raise from time to time for various expenses by public subscription, balls, entertainments, and fairs, the unnecessary fire losses inflicted upon the community by the inefficiency of volunteer operations and the unavoidable waste of expenditure due largely to divided and irresponsible control of finances, it is evident that the net result is a large tax upon the public where these conditions obtain.

3. WORK OF THE NATIONAL BOARD—Since 1890 the National Board of Fire Underwriters has been engaged in investigating fire departments, as well as water works and other fire protective conditions in cities, with the purpose of recommending improvements. From 1890 to 1904 this work was performed by single inspectors, during which time some 747 cities and towns were visited and reports issued. During twelve of these years fire chiefs of long experience, former presidents of the fire chief's association, were employed. After the Baltimore fire of 1904, following several other conflagrations, the National Board enlarged the scope of the work and employed a number of civil, mechanical and electrical engineers to study into conditions from the viewpoint of the modern efficiency engineer, to locate the weak spots and advise methods of improvement.

The National Board Engineers, after inspecting and reporting upon over 500 cities in the United States, including practically all over 25,000 population and many of smaller size, prepared a Standard Schedule for Grading Cities and Towns in the United States with Reference to Their Fire Defenses and Physical Condition. This Schedule consists essentially of standards for different sizes of departments, modified by local conditions, and gives a basis from which the relative value of the fire departments of the country can be determined. In addition, the Schedule covers other features of protection, such as, Water Supply, Fire Alarm System, Building Construction, Protection of Hazards and the Physical and Structural Conditions of the city. Much of the data given hereinafter is taken from the above-mentioned Schedule or is an amplification of the features covered by that publication.

ORGANIZATION

4. **BASIS**—In organizing a fire department the basis of maintenance is the first point to be considered. Shall full-paid, part-paid, or volunteer firemen be employed, or a combination of some of these? It is now generally recognized that a small number of full-paid men constantly employed are better able to handle ordinary fires than a large number of volunteers or call men. Yet, in small cities, where it is impracticable to employ more than one or two companies, conditions are generally such that at times additional men are needed and it is advisable that either call men or volunteers be included in the personnel. With the general use of automobile fire apparatus, the tendency toward full paid or part paid fire departments in small communities has been accentuated, as the greater radius of operation of motor apparatus permits covering an extensive territory by one or two companies.

5. In very **small communities** a paid department is impracticable, as the fire service is too infrequent to justify supporting paid men. Cities of less than 10,000 population rely almost entirely upon volunteers. Occasionally towns of this size employ a full-paid chief, but the common method is to pay the chief officer a moderate sum, say $300 a year, sufficient to reimburse him for time lost in fire department work and expect him to rely on his trade or business for his main support. This method of partial payment is commendable, as the chief whose services are purely voluntary is not likely to spend any more time than is imperative on the fire department, considering the office one simply of honor and a tribute to his personal popularity, whereas acceptance of a salary is likely to, or should, imply the acceptance of the duties of the position.

6. Cities of from **10,000 to 20,000 population** in most cases support a few full-paid firemen, assisted ordinarily by volun-

teers or call men. A force of full-paid firemen, including chief, drivers and engineers, with part-paid call men, appears to be an accepted practice for cities of this size, where the ordinary fire service is not frequent enough to warrant a complete full-paid department. While in many such cities and some larger ones the volunteers have done valuable work, yet their efforts are too undisciplined, inefficient and often misdirected to make their assistance reliable. Quarrels between rival volunteer companies, interference of politics and difficulty of controlling such members are compelling arguments for substituting full-paid men whenever the city can afford it.

7. In cities of from 20,000 to 100,000 inhabitants the methods vary greatly in different sections of the country. In the East such departments are largely composed of volunteers or call men, while in the West and South full-paid departments are the rule. A few Eastern cities of even as large as 80,000 inhabitants have volunteer departments composed of companies organized as social clubs, with 50 to 200 members each, with a few paid men and officers. In these cities, sentiment is gaining headway toward the organization of full-paid departments.

8. SUPERVISION—This subject has been a difficult one for municipalities. The old method of control by a committee of the city council has largely given way to a so-called non-partisan board of fire commissioners, or to a single commissioner. The non-partisan board is usually a bi-partisan board and its operations are frequently conducted upon the principle of "You vote for my man and I'll vote for yours."

9. A single commissioner appointed by and responsible to the mayor, leaving the management of the department to the chief, has been found more satisfactory. Especially is this good where the chief is protected from unwarrantable interference by civil-service or tenure-of-office laws.

10. In many cases the multiple-headed commission is subject to frequent change, followed by changes in management and demoralization of the department. Sometimes the National Board has recommended that one commissioner be appointed each year for a term of years, so as to avoid sudden shifts of policy; more frequently the National Board has recommended a single commissioner appointed for a long term and removable only for cause.

11. In New York and in some other states, and in the many cities which have adopted Commission Government, the fire departments are usually under the supervision of a Commissioner of Public Safety, who generally controls also the police, building, and health departments. This has generally worked out well in practice, especially where appointments and promotions are guarded by civil-service laws. The Commissioner usually handles finances and makes appointments and promotions. A good method in cities up to 100,000 population is to entrust appointments and promotions to the Fire Chief, who is almost invariably of long experience in the department and interested only in securing efficiency. In any case assignments and transfers should be controlled by the chief alone.

12. Tenure-of-office is necessary; where the chief is subject to annual appointment by the mayor or council, political or personal influences inevitably creep in and the appointment of the chief for an indefinite term, subject to removal only after due trial, is the most satisfactory method so far devised.

13. ENLISTMENT, PROMOTION, AND RETIREMENT—The method of appointing best adapted for any city depends largely upon the size of the city and local conditions. In large cities the chief cannot know all his subordinates and certainly cannot be acquainted with any large percentage of applicants for appointment; in these places the civil-service method is the most satisfactory yet devised for appointments. The officers of some of the large departments have rather freely criticised civil-service methods but it is doubtful if they have anything better, or nearly as good, to offer. Where civil service is properly applied, the past record of applicants is looked into and they must successfully pass a rigid physical examination before taking the mental examinations. There is in some quarters a false impression that civil-service methods have resulted in the appointment of a class of men better adapted to clerical work than the physical labor required in city fire departments. While the mental examination may bar out otherwise desirable applicants, yet in the large cities there is no lack of applicants and it is readily practicable to make physical requirements such that all the men getting on the eligible list shall be competent to become able-bodied firemen. The varied emergencies and requirements of modern fire department work are best met by men capable of passing reasonable mental as well as the physical examinations, rather than by men whose chief asset is mere strength.

14. In smaller cities, say up to 40,000 or 50,000 population, it is quite possible for the chief to select his subordinates from among the applicants, and, in fact, this method in smaller cities has been successful. The practice is not so liable to abuse as might appear at first sight, as the chief is usually a fireman of many years' experience, with the interest of the service and city at heart and desirous of selecting the best available men. Even in the smaller cities some mental examination is desirable and certainly a rigid physical examination.

15. When the **eligible list** is established appointments should be made by the chief rather than by a council committee or the mayor. New appointees should be on probation for a reasonable time, say six months. They will be under the eye of company officers and the chief, and appointments should not be made permanent until the officers have had opportunity to observe their work at fires and determine whether they will make successful firemen. Once appointed, they should be made secure in their position during good behavior and efficient service. For promotion, good record and seniority should be considered in making up an eligible list. Examinations for promotion to company officers should be largely competitive, but for battalion chief and higher positions good service and seniority should have a greater weight.

16. For **retirement** the National Board has recommended that members be retired from active duty on reaching sixty-two years, unless at that time they are unusually efficient. Sixty-two years is the age for retirement from the United States Army and Navy. The exemption from this rule of members of unusual efficiency enables the department to avail itself of the accumulated experience of the higher officers, who should have no manual labor to perform. In connection with requiring members to retire on account of age there should be means provided for pensioning men for long service or disability. Often a volunteer or part-paid department will have a sick benefit or a death benefit fund; on establishing a paid department these become a nucleus for a pension fund. Money for such purposes may be obtained by apportioning part of the taxes, fines assessed upon members of the department, gifts from citizens and by annual appropriations. Pension rules generally provide that members may retire on half pay after twenty to thirty years' service, if over fifty-five years of age, or after ten years' service if partially disabled, or at any time if permanently disabled when on duty. There should be a minimum age for voluntary retirement or pension, so that the city may not be deprived of the services of experienced men in the prime of life. In New York City the pension law permits members to retire on half pay after twenty years' service regardless of age; thus a man may retire at forty-one, when his services should be of value to the city for many years. Rules should also provide for small pensions for widows, minor children and dependent parents of deceased members.

17. COMPANY ORGANIZATION AND MAINTENANCE—In the ordinary full-paid department the men will be collected in a comparatively few companies of sufficient strength to man all the apparatus at the station. If call men or volunteers are included in the department then enough full-paid men should be assigned to get the apparatus to a fire and get to work. In a part-paid engine company, for instance, the engineer, two drivers and one other member, preferably the captain, should be full-paid, so that at least two men will be on duty during meal hours, enough to get the apparatus to the fire; for a hose or ladder company, at least two men must be full-paid. This does not allow for days off or sickness, for which permanent substitutes should be employed, who will shift from one company to another to fill in.

18. FULL PAID DEPARTMENT. The Standard Schedule of the National Board of Fire Underwriters recommends a minimum strength of companies as given in the following table:

Companies	Least Number of Men on Duty	
	Day Time	Night Time
Within or Near High Value District:		
Steamer Company	7	9
Pumper Company	6	8
Ladder Company—manual raising	7	9
Ladder Company—mechanical raising	6	8
Hose Company	5	7
Water Tower Company	1	1
In Other Districts:		
Steamer Company	5	7
Pumper Company	4	6
Ladder Company	5	7
Hose Company	3	5

19. It is the concensus of opinion of fire department officials that greater company strength is necessary at night than during the day. The handicap offered by darkness, locked doors, more severe cold, and other features seems to justify this opinion. In the past, most of the departments operated on the so-called single shift system, where the men received certain time off, ranging from one day in three to one day in ten and, in addition, were permitted meal periods, usually three each of one hour's duration, with the result that company strengths were automatically stronger at night than during the day. For instance, in a 14-man company where men get two weeks vacation, one day off in five and 3 hours for meals, during a large part of the time, one man would be on vacation and three on days off. This would leave 10 men on duty at night, but during the day time, there would be three hours in which the company would be reduced to six men, and six hours in which it would be reduced to seven men, or for a total of nine hours during the day there would be only six or seven men available to man the apparatus.

20. TWO PLATOON SYSTEM—In recent years, many cities have placed their departments on a two-platoon basis. Under this system, the department is divided into two equal shifts. Thus, the same number of men are on duty at night as during the day. The most common form of operation of the two-platoon system is to have periods of 10 hours and 14 hours operation, although many departments have each shift on duty for 24 hours, making the men bring their meals or prepare them at the station. It is considered desirable to have officers alternate in such a manner as to be brought in contact with men of each shift; this is especially so where one of the officers is in charge of a station and apparatus with title of Captain and the other is a subordinate with title of Lieutenant. Many departments give each officer equal rank and hold him responsible for men and equipment during his time of duty.

21. The change from single shift systems to two-platoon requires an increase of 33 to 50 per cent. in men and cost of maintenance, depending upon whether an attempt is made to maintain an average of the previous day and night strength, or the previous night strength. Where the strength of each platoon is only equal to the previous minimum day strength, it is impossible for members of the company to make inspections or to attend drill schools. The ideal condition is to have each platoon equal to the minimum required night strength as given in the table above and to use the two additional men thus available in the day time, over the minimum specified, as inspectors in the fire prevention bureau or in other fire department work.

22. Companies within or near high value districts, which districts are usually made up of buildings of large size and considerable height, must be stronger than those in purely residential sections, as there will be greater need of quick action and of the laying of two lines by a company and, in addition, it takes more men to handle the hose and to do rescue work in buildings of the height usually found in such districts.

23. In a few cities drivers or chauffeurs do not perform fire duty. Where this condition exists, the minimum number of men necessary must be one greater than as given in the table. This is also true where an operator is left at the hydrant, as is sometimes the case where pressures are high and streams are used direct from hydrants.

24. In a number of cities, **auxiliary squads** have been established in which a company of men, sometimes equipped with apparatus carrying hose, but usually with apparatus having only chemical equipment and minor tools, is so located that it can cover a very extensive section of the city. These squads were first established with the early introduction of the automobile touring car, before automobile apparatus had been perfected for other fire service. The intent was to quickly transport additional men to the scene of the fire and thus augment undermanned companies. Some few cities still maintain such squads, but in general with the more or less complete motorization of fire departments there no longer exists any need for these auxiliary squads of men, simply as an organization to increase the manual strength of the force at the fire. This desired increase can be obtained sufficiently quickly by sending in a second or third alarm, thus calling regular companies which have full equipment in case it is needed.

25. With hand and horse drawn apparatus, it was common practice to maintain as separate companies apparatus carrying only large chemical tanks. This was because the introduction of chemical tanks on hose wagons in many cases made them too heavy. Some departments have maintained these **chemical companies** after the department became motorized, putting the chemical tank on automobile chassis. The men on these chemical companies are usually available after the first few minutes of a fire to help out the engine or ladder companies which have responded. Where auxiliary squads or chemical tanks respond to alarms, the men are thus available as an auxiliary force to aid the other companies. It is considered that the strength of the other companies may be reduced by one man without materially affecting the fire methods.

26. One of the advantages claimed through the use of the two-platoon operation of the department is that a large reserve force of trained men is thus provided in the off-shift platoon. In many cases, particularly in the larger cities, this is more theoretical than actual. Usually the law under which a department changes to the two-platoon gives the chief of the department power to call the off-shift at time of serious fires or for other emergencies. Few of the larger cities have yet worked out adequate means of calling these men and the lack of transportation renders it problematical as to whether they would be available at night. In the smaller places, where tower bells and whistles can be heard, the problem is more easily worked out and records show that in many communities an average of 75 per cent. of the men has responded upon call. When a fire occurs at or near the period of change of shifts both platoons are available, thus giving a largely increased fire force. The method of using the off-shift men varies. Most cities require the men to respond to the fire. A few places have adopted a better scheme; the men are required to respond to headquarters or some other station and to man reserve apparatus located there, thus covering the city for a second fire and being available on call for the first fire if their services are needed. With these methods of procedure, the men are able to keep suitable working clothes on the reserve apparatus and there is also the advantage of additional equipment responding with them.

27. In a department operating on a **call basis,** where members receive some pay or are fined or otherwise disciplined for not responding to fires, it is assumed that a company strength on the basis of 4 call men equalling one paid man is sufficient. **Volunteer departments** often have large membership. This is detrimental to good service as it works against harmonious action and at times results in such an excessive crowd at the fire that efficient service cannot be carried out. The membership of a volunteer department should be on a basis of 8 volunteers equalling one paid man.

28. DISTRIBUTION OF COMPANIES AND APPARATUS. In considering the distribution of companies the shape, size, and location of the mercantile and other high value districts must be given consideration. The Grading Schedule of the National Board of Fire Underwriters specifies that companies should be within the following distances of every point in the district, measured by the most direct traveled route.

DISTRICT.	Horse-drawn.		Automobile.	
	Engine or Hose Co.	Ladder Co.	Engine or Hose Co.	Ladder Co.
Mercantile or manufacturing . . .	½ mile	¾ mile	¾ mile	1 mile
Closely built residential	1 mile	1½ miles	1½ miles	2 miles
Scattered residential	1½ miles	1½ miles	3 miles	3 miles

29. In mercantile districts a limiting feature will also be the amount of apparatus which should respond to first alarms, because it is considered that the number of engines necessary to respond on first alarms should be within a mile of the center of the district in the case of horse-drawn apparatus and within 1½ miles of such center in case of motor apparatus.

30. Frequently where departments have grown from volunteer to part-paid and then to full-paid, companies are still found in the old volunteer stations which were apt to be located without regard to the needs of the city as a whole, but more as neighborhood jealousies or local organizations dictated, so that in the business section of one large city companies are one-quarter of a mile apart and then there is a gap of one and one-half miles without protection. In such cases the National Board has often recommended relocating the existing companies.

31. The **topography** of the ground is often a governing feature. Where cities are fairly level, so that the lower value districts extend in three or four directions from the mercantile districts, a fairly even spacing of companies, as outlined at the beginning of this section, is feasible. On the other hand, where deep valleys intersect the closely built districts, or where the town is built along a steep side hill, companies must be located more irregularly and with a view to protecting all sections; the natural obstacles will frequently require companies to be apparently rather closely spaced, while, in fact, the running time between the districts covered may be much greater than is evident on account of the round-about route to be traversed. The city of Pittsburgh is a good example of this class as it is cut up by two river valleys, a number of deep ravines, steep bluffs and large railroad yards, so that as compared with other cities of similar size a much greater number of companies is necessary for the protection of the various districts.

32. Chemical apparatus should be so distributed that at least two will answer all first alarms in high-value districts and one in other districts. Modern practice tends largely toward the substitution of combination chemical and hose wagons in place of separate chemical engines and plain hose wagons. With horse-drawn apparatus the combination machine is sometimes inadvisable, as the requisite amount of hose, men and other appliances cannot always be carried on account of hills or poor streets, but with motor apparatus this is no longer a limiting feature and it has been found in practice that 1,200 ft. of hose, two chemical tanks and a full complement of men and tools can be readily carried by one automobile, so that with the introduction of motor apparatus city departments are generally installing chemical tanks with every company. Motor apparatus has made it feasible also to give better ladder protection to outlying sections not sufficiently built up to warrant the installation of a ladder company, as such machines can readily carry thirty-six feet of ladders, sufficient for work around the ordinary two and one-half story dwelling. It is found in practice that the number of ladder companies in proportion to hose companies will be, roughly, for the average city, between one to three and one to four, depending upon the topography, etc.

EQUIPMENT OF PUBLIC DEPARTMENTS

33. The equipment of modern fire departments includes: Steam fire engines, gasolene fire engines, chemical engines, fire boats, hose wagons (with and without chemical tanks), ladder trucks (of several types), water towers, fuel wagons, automobile apparatus, horses, hose (of three or four different sizes), ladders, portable chemical extinguishers, appliances for handling powerful streams, and a large list of minor appliances.

34. The proper equipment for a given department is largely dependent upon the topography of the city, the character of the buildings and condition of the water supply. Where the waterworks system is so designed as to provide an ample supply of water at a minimum hydrant pressure during draft of seventy-five pounds or over the fire department can be kept upon a direct hydrant stream basis until buildings of over four stories begin to be numerous in the congested section. One or more engines in service or in reserve may be desirable to protect the higher buildings or those too far from the hydrants for effective hydrant streams; for cities of over 30,000 population it is advisable to have about one-third the companies provided with engines, to furnish the more powerful streams. Frequently some of the residential sections will be at considerably higher elevations than business districts and companies in these locations must be equipped with fire engines.

35. The **ideal equipment** for an engine company in a city able to afford it consists of two pieces, a pumping engine and a combined chemical engine and hose wagon, the latter ordinarily known as a combination wagon. A good arrangement in small or medium sized cities is to have about half the companies equipped as above, which will furnish adequate chemical service, and the other half equipped with combined pumping engine and hose wagon. This latter piece of apparatus must, of course, be so manipulated at a fire that after the one or two hose lines needed are stretched from the hydrant to the burning building, the engine will reach the hydrant and connect its suction as quickly as possible; there will naturally be somewhat more delay than if a separate engine and hose wagon are provided, but this delay should not be more than two or three minutes in most cases, even when two lines of hose are laid, as shown by tests of a crew trained to the work.

36. The **triple combination,** as it is usually called, consists of a combination of pumping engine, chemical tank, and hose body. This machine has, in recent years, come into use to a large extent in small and medium sized cities and residential districts of large cities. It is especially valuable in the many localities where the pump is seldom needed, as, for instance, in cities where the water pressure is sufficient, in most sections or under most conditions, for effective direct hydrant streams, but where there are occasional high elevations or weak spots in the water distribution system and the ordinary hydrant pressure is inadequate; it will also take the place of a reserve engine for use at serious fires in high-value districts. For general installation in congested districts, this type of apparatus is not the most desirable, for the obvious reasons that its use in furnishing chemical service precludes its pumping from a hydrant or other source of water supply, without considerable delay at what is likely to be a critical moment; and because too much equipment is carried on one set of wheels and would be lost in service in case of disablement. This feature is so important that the National Board recommends in all cases that not less than two hose companies be sent to every alarm.

37. FIRE ENGINES—Whenever the hydrant pressure is too low for direct streams, or in localities at higher elevations, fire engines become necessary. Especially in small cities where the water works are of limited capacity, fire engines are necessary for fires that have got under headway before the department can get to work, in order to save adjoining buildings. As indicating the need of intelligent oversight of the operation of fire engines and of regular and systematic tests, investigation has shown that where such tests are not made, even in well managed departments, defects often exist which may continue unsuspected for considerable periods and they become manifest under the stress of a large fire, where the engine is called upon to deliver its full capacity under suitable working pressures. Furthermore, regular tests are a most valuable drill for engine crews, for in only a few departments do they receive sufficient training in operating engines to capacity. The breakdown of an engine at a fire or the inability of the crew to operate it to capacity may be the direct cause of confusion and the needless loss of property and perhaps of life, to the discredit of the department.

38. STEAM FIRE ENGINES. The steam fire engine is now almost obsolete and where still maintained it is being superseded by the motor pumper as rapidly as funds can be obtained. The first use of the gasoline engines in fire service was in connection with small hand-drawn equipment of only a few hundred gallons capacity. These were extensively used in farming districts and small villages and are still found in many of these sections. With the full development of the touring car type of automobile one or two manufacturers conceived the idea of installing a pump on the standard chassis and using the motor of the automobile to operate the pump for fire service. The first machines were crude and inefficient but improvements developed rapidly and in 1913, in a 12-hour endurance test at the annual convention of the International Association of Fire Engineers, it was demonstrated that, with proper design and good workmanship, the motor pump far exceeded the steam fire engine in its ability to maintain a constant discharge for long periods of time. The operation of motor pumpers continuously for several days has been a fairly frequent occurence at fires in recent years. Several manufacturers, dealing exclusively in fire apparatus, have developed the motor pumper to a high degree of efficiency and to capacities up to 1,500 gallons a minute. In recent years many manufacturers of commercial trucks of recognized quality have adapted their apparatus to fire service by installing a pump and hose body on their standard 2-ton or heavier trucks. In general, these adapted or assembled pieces of apparatus are of relatively small capacity ranging from 250 to 600 gallons. This is because of the use of motors of less horse power, usually with only 4 cylinders, than has been the case with the manufacturers who are building only fire apparatus. In the earlier machines and in most of those of a 1,000 and 1,500 gallons capacity, the motor had cylinders of large bore and long stroke and the revolutions per minute were limited to a piston travel of about 1,000 feet per minute. Recent development of automobile motors has been toward much higher speed and most of the apparatus composed of commercial chassis and pump has been provided with motors which can be operated safely at or around 1,800 revolutions a minute with 1,500 to 1,600 feet per minute piston travel.

39. PUMPS—In regard to the pump, for all except village service, two good fire streams should be available under ordinary working conditions, which, with the modern use of hose with smooth lining and nozzles of good size and discharging capacity, means an actual delivery of 500 to 600 gallons. With all pumping apparatus the slip may be expected to increase with use and other conditions will tend to reduce the capacity of the pump, so that a capacity of 700 gallons is not too much for most cases and for metropolitan service even larger capacity may be desirable. City service at serious fires when the maximum engine capacity is needed will most often call for such lengths of hose lines and sizes of nozzles as to require an engine pressure of 120 to 150 pounds, with pressure up to about 200 pounds for fires in high buildings or for suburban service.

40. RECIPROCATING PUMPS usually require a more complicated power transmission system than the others, as generally two or more pump speeds must be provided for. This type of pump is, however, reliable, and easily kept in good condition if given competent attention. In order to overcome transmission troubles, one type of reciprocating pump has been developed which has two or more cylinders with transmission so geared that for large capacity all the plungers will be operated at moderate pressures, and for high pressures the entire power of the motor may be diverted to one plunger, giving high pressure with less discharge.

41. ROTARY PUMPS, because of their compactness and the simplicity with which power may be transmitted at various speeds, are well adapted to this service. Some of the early makes were unable to develop high pressures; these have been generally superseded. Some makes are not well designed for efficiency, and under test show much loss of power from high slip and poor transmission.

42. MULTI-STAGE CENTRIFUGAL PUMPS have been considerably improved in recent years for fire engine service; although somewhat heavier and more expensive than rotary pumps, their ability to stand hard usage and their property of automatically regulating discharge and pressure are features tending to make them a desirable type for fire service; they are especially adapted for use with high speed gasolene motors.

43. With any type of pump, the requirements desirable for fire service are flexibility of operation, that is, ability to operate over a wide range of pressure, and the power required for good fire fighting; the National Board has recommended, and some of the leading fire departments have adopted, the following specifications for motor pumping engines:

44. The engine to be able to deliver 700 gallons per minute (or whatever its rated capacity may be) at 120 pounds net pump pressure, 50 per cent. of its rated capacity at 200 pounds net pump pressure, and 33 per cent. of its rated capacity at 250 pounds net pump pressure, with a suction of at least 10 feet. The length of hose lines and sizes of nozzles to be such that above results will be obtained at test; the full capacity test to be of two hours duration and other tests of not less than one half hour duration each.

45. FIRE BOATS are used by many cities having valuable water front property, which is often difficult of access except from the water side. They are essentially large tug-boats, equipped with fire pumps of 3,000 to 12,000 gallons nominal capacity and with larger boilers than would ordinarily be installed in tugs of like tonnage. The older boats have vertical reciprocating pumps of similar design to land steam fire engines; recent boats are fitted with centrifugal pumps direct connected to steam turbines.

46. Boats should be of light draft for harbor work and the larger sizes should be equipped with twin screws for quick turning. Boats of recent construction have steel hulls and steel deck houses; plank-covered decks are preferable to metal, as steel decks are slippery. There should be steam or electric steering gear and electric light plant, with searchlights. The boat is usually about 110 ft. long, 25-ft. beam, and 10-ft. draft. There should be connections for 3½-in. hose conveniently arranged forward and on each side, brackets or sockets for rail pipes (of self-holding type), and boxes or reels for the hose; a few boats have telescopic masts with elevated nozzle. In some of the later boats, propulsion is obtained by electric motors, using current from generators which can be operated from the steam turbines for the centrifugal pumps. For river work or operation in tideways, it may be advisable to provide spuds which can be lowered to hold the boat in position.

47. The following are examples of well designed boats, installed in recent years:

48. Fire boat "David Campbell," Portland, Ore., installed in 1913, 242 gross tons, steel hull, length 125 ft., beam 25½ ft., draft 8 ft. 7 in. Two Ballin water-tube boilers, each 1,400 h.p., oil burning; engines, non-condensing, 14 in. by 20 in., to twin screws. Speed, 16 miles per hour. Four 10-in pumps, two-stage centrifugal in two double units, each driven by a 600 h.p. Curtis steam turbine; rated capacity 9,000 gallons per minute at 1,800 revolutions; under test these pumps delivered 9,550 gallons per minute at 144 pounds net water pressure and 4,220 gallons per minute at 320 lbs. water pressure. Ten-inch turrets fore and aft; turret on telescopic tower raising to 37 ft.; 4 four-in turrets each side. This boat carries 2,000 ft. of 2¾-in. 400 ft. of 1½-in., and 300 ft. of chemical hose; four ladders, 13 to 26 ft. long, and two 80-gallon chemical tanks. 3½-in. hose and extra 2¾-in. hose is carried on a boat tender wagon. The boat cost about $120,000. The crew is 21 men, including a master, pilot, 3 engineers, 3 stokers, captain, 2 lieutenants, and 10 hosemen. The least number on duty is 10 by day and 15 at night.

49. At New York City, the Fire Boat "William J. Gaynor" was put in service in 1914. Steel hull; gross tonnage 270; length 118 ft.; beam 25 ft.; draft 13 ft. 4 in. Double, compound inverted engine, 17×36×25 stroke; two Babcock & Wilcox water tube boilers 950 h.p.; hard coal burning. Steam steering gear; speed, 12 miles per hour. Two turbine pumps; total rated capacity at 1,800 revolutions, 7,000 gallons per minute at 175 pounds water pressure; under test they delivered 7,250 gallons per minute at 181 pounds water pressure. The boat cost $110,000. The crew is 34 men, including a captain, 2 lieutenants, 7 engineers, 2 pilots, 15 privates, and 7 stokers. Payroll for the year 1917, $50,220.

50. At Jacksonville, Florida, a wooden submarine chaser was purchased from the Government and fitted up as a fireboat in 1922. Length of hull 110 feet; breadth 14 feet; depth 8 feet; draft, 7 feet; displacement 110 tons; two 220 horse-power 6-cylinder air-starting and reversing "Standard" motors each driving a 48-inch diameter by 42 inch pitch three-blade propeller. Pumping equipment consists of 4 three-stage 8-inch centrifugal pumps, speed 1500 R. P. M., capacity 1750 gallons per minute, connected directly to 300 horse-power 8-cylinder Sterling engines. Boat is not designed for sleeping quarters. Two hose boxes contain each 1,000 feet of hose.

51. CHEMICAL EQUIPMENT. The chemical tanks are filled with a solution of bicarbonate of soda (baking soda or saleratus) in water. A bottle of sulphuric acid is suspended in a cage in the tank, so that overturning the bottle or loosening the stopper will release the acid, forming carbonic acid gas, which forces the contents of the tank out through the attached hose. The proportions of acid and soda are such that the acid is completely neutralized and little or no damage results to fabrics which may be wetted by the mixture. The carbonic acid gas, being a fire-killer, adds somewhat to the extinguishing power, especially in any confined space.

52. There are four types of chemical apparatus in use: the **Babcock, Champion, Holloway, and Kanawha.** In the Champion the acid is dumped by revolving the tank; the Babcock is an improved Champion with paddles for stirring the mixture; the Holloway has a fixed tank with the acid bottle in dome at the top and means for tipping the bottle. The Kanawha is radically different; no acid is used but an extra tank of compressed air is carried to furnish power for expelling the liquid which may be a soda solution or any other containing a fire-deterring gas; in this type little gas is evolved and an air compressor must be provided at the station for recharging. For discharging, chemical tanks are fitted with 200 to 300 ft. of ¾- or 1-in. hose; in straight chemicals this is usually on a reel, and on combinations in a metal "basket."

53. With a development of automobile apparatus another variation of this idea has come into use. A small rotary or centrifugal pump of 50 to 200 gallons capacity is connected to the motor, and a plain water tank of 40 to 50 gallons capacity is used in place of the chemical tank. On approaching the fire, if the 2½-in. hose can be laid from the hydrant in the usual manner it will be connected to the suction of the booster pump. Meanwhile, until this connection is ready, the pump takes suction from the tank, discharging through the chemical hose, which can be handled by one man. Thus, in a call or volunteer department, two men can get a small stream on the fire until the arrival of additional help, while at the same time the large hose is paid out and ready for quick use.

54. LADDER TRUCKS—There are four general types of ladder trucks in use by fire departments: "Aërial," "plain tiller" or "city," "service," and "village." Any of these may be fitted with a chemical tank, making a "combination truck."

55. Aërial ladders are of two classes: Hand-raising or quick-raising, referring to the main ladder, which is secured to a revolving turntable at the front of the truck. Few of the manually-raised aërials have been constructed in recent years and many have been converted to the quick-raising type. In these, all or part of the weight is balanced by springs or air pressure so that the heavy ladder may be elevated more rapidly by a small force; in some of the latest types the ladder is raised by a spring or air hoist, and is lowered manually by reversing the operating mechanism, or by electric motor. Aërial ladders are regularly made in four sizes, from 55 to 85 ft. A few have been constructed with extensions to 100 ft. The National Board considers that at least one more man is required in companies having manually raised ladders than with quick-raising ladders. This makes the maintenance cost of the company with the quick-raising ladder appreciably less.

56. The **plain tiller trucks** have become unpopular, as it is found a service truck can carry ladders up to 60 ft. and beyond that the aërial ladder is easier of operation. The service truck is without tiller and is short-geared so as to turn corners readily. It is lighter than the long coupled tiller truck, carries practically the same equipment, and is a most useful apparatus in any district where buildings of not over four stories are encountered. The longest ladder is usually from 45 to 60 ft. A typical ladder outfit for this truck would be a 55, 45 and 18-ft. extensions, 30, 25, 20 and 12-ft. straight ladders, a 12-ft. roof ladder, and two 12-ft. pompiers.

57. For residential districts a **combination service truck** with 45 or 50-ft. extension ladder and 40-gallon chemical tank has been found most valuable.

58. In some outlying sections, where only one company may be located, a combination truck and hose wagon, consisting of service truck with 40-ft. extension, 35-gallon chemical tank, and hose box for 600 to 800 ft. of 2½-in. hose is sometimes installed. With motor apparatus, this type will likely prove valuable in many residential districts now at considerable distance from a ladder company.

59. The **village type of truck** is confined mainly to small volunteer departments, where apparatus is hand-drawn or only one horse is provided. It is practically a skeleton service truck with few ladders and little space for minor equipment; such trucks seldom carry over a 40-ft. extension ladder.

60. The **equipment** carried on ladder trucks in various cities includes: Axes, bale hooks, brooms, buckets, burst hose jackets, cellar pipes, chemical charges, crowbars, claw tool, deluge sets, door opener, fire escape, forcible entry tools, forks, gas keys, hand pumps, hose, hose-roller, hose straps, hose shut-off, ladder pipe, lanterns, life net, life belts, lock breakers, marine torches, mauls, megaphone, open, shut-off and distributing nozzles, nozzle holders, picks, plaster hooks, ram and wall cutter, ropes, rope gun, roof cutters, siamese couplings, "Y" couplings, signal flags, sledges, shovels, spare poles, eveners and whiffletrees, smoke masks, squeegees, surgical kits, wall hook and chain, wire cutters, rubber gloves, tarpaulins, tools, small saws and augers, and torches. No one truck may carry all of these and some of the tools are not essential, but all should have lanterns, chemical extinguishers, plaster hooks, axes, crowbars, door-openers, roof cutter, wire cutters, ropes, shovels, forks, brooms, surgical kit, life net, and water-proof covers. Much other equipment, especially the cellar pipes, hose rollers, life guns, marine torches, smoke helmets and deluge sets are frequently valuable in closely built sections.

61. TRACTORS FOR HORSE-DRAWN EQUIPMENT. The obvious advantage of automobile apparatus over horse-drawn was such that as soon as automobiles became sufficiently dependable various schemes were adopted for changing over existing equipment so as to make it motor propelled. The first general scheme was by the use of tractors. The tractor problem is about the same whether applied to an engine, ladder truck, or other piece of apparatus. The most common arrangement is a two-wheel device, either driven directly from a gasolene engine or with each wheel equipped with a separate electric motor supplied with current from storage batteries, or from a generator driven by a gasolene engine. Some tractors have one or two steering wheels in addition to the driving wheels. The single steering wheel has not worked out in practice. It is difficult to keep the third wheel in line, especially where unpaved streets and rutty roads must be traversed.

62. Most of the earlier automobile fire apparatus was fitted with pneumatic tires of the touring car type but solid or cushion tires were soon found to be preferable from the standpoint of safety and economy. Then followed the development of the truck type of pneumatic tires which most chiefs at present consider reliable and economical because they reduced to a minimum the vibration of apparatus and the consequent breakage of parts. Solid tires on cushion wheels designed especially to reduce the vibration are favored by some fire departments. For the rear wheels of the heavy pieces of apparatus, dual tires are used extensively to prevent skidding and to secure greater traction and bearing surface. While the dual tire reduces skidding somewhat, this may be overcome by proper tire construction or the use of anti-skid devices or both. For economy and long wear, it is probable that a large single tire will be found most satisfactory.

63. APPLIANCES FOR HANDLING POWERFUL STREAMS—These include water towers, turrets, ground pipes, deluge sets, and siamese connections.

64. Water towers are elevated turrets for discharging streams into the upper stories of buildings. They are usually arranged with a heavy mast on a revolving turntable, similar to an aërial truck. The mast elevates 30 to 40 ft., a sliding extension rising to 55 to 65 ft. The two leading types are the Hale (now called the American-LaFrance) and the Champion. The Hale tower is pivoted over the front of the truck with the nozzle projecting at the rear; the Champion tower is arranged in reverse position with the nozzle forward. The Hale tower is usually raised by water or chemical pressure and the Champion tower by hand; later towers of American-LaFrance make are spring-raised. The extension tip is extended by hand. A few towers of other makes have been placed in service, some with hydraulically raised telescopic towers up to 75 ft.; these are slow of operation and difficult to control. Towers have a working deck about five feet above ground, often with one or two turret nozzles; inlets are provided at each side and rear so that water may be directed to tower or turret as desired. Towers are needed in cities having a number of buildings six stories or over in height. In most cases the towers are kept in reserve at a centrally located station; or only horses and a driver are provided to take them to alarms, laddermen being detailed to handle them, if needed.

65. Recent installations of water towers are of the automobile type, usually with front tractors or with storage batteries and motor drive for each wheel. Some horse-drawn towers have been rebuilt for motor drive. As this class of apparatus usually attends a limited number of alarms with short runs, the saving in maintenance over horse-drawn towers is appreciable. The National Board has recommended that water towers be provided in high-value districts having 10 buildings of 6 stories and higher; a tower to be located within 1½ miles of every such building.

66. Turret nozzles are usually mounted on hose wagons; occasionally a hose wagon in reserve is fitted with a turret, filled with 3-in. hose and stationed in the mercantile district, for serious fires. Some cities have turrets mounted on 2-wheel trucks or on small 2-wheel platforms so that they may be drawn behind wagons or ladder trucks; these may be easily handled in narrow alleys where wagons cannot readily drive, while at the same time leaving the wagons free to move about. At least one turrent pipe to every fourth wagon is necessary and more are desirable.

67. Ground pipes are small turrets arranged to stand without holding. **Ladder pipes** are pipes similar to small turret pipes, more or less permanently secured to the base section of an extension ladder, usually an aërial ladder, and so arranged that the streams may be directed into upper floors of buildings. There are numerous varieties of these; some arranged to be operated from the ground or the drivers' seat and through a considerable arc in each direction. For some of these, single lines of large hose are used, and for others, two lines of 2½-in. hose siamesed.

68. **Deluge sets** are short lengths of larger hose (usually about 14 ft. of 3½-in.) with large nozzles and tips, 2- to 4-way siamese, and rods or small platforms for steadying the nozzle. They may be used in places inaccessible to a wagon turret and are more easily shifted. As a means of concentrating the output of one large or two small engines into a powerful stream they are of great value.

69. **Siamese connections** are usually carried by hose wagons where long lines must be laid, especially from hydrants. By laying two lines and siamesing at the last 50 ft. about three fourths of the friction loss is eliminated. By the use of 3-in. hose and siamese the expense of fire engines may be saved by cities having only moderate hydrant pressures.

70. FIRE DEPARTMENT RESCUE WORK—In recent years, following the example set by New York City, several of the larger cities have installed one or more rescue squads, consisting of a company of specially trained men provided with an automobile carrying a full assortment of smoke helmets, lung motors, oxygen tanks, forcible entry tools and various other emergency equipment. The men and apparatus are usually assigned to respond to second alarm fires, but are depended upon mainly for special calls and are used extensively for other than fire department work. The records show that they have been the agency through which numerous persons, overcome by gas or who have drowned, have been resuscitated. These rescue squads are of particular value in getting at smoky fires in confined spaces where firemen with ordinary equipment could not penetrate.

71. SALVAGE WORK—In many of the larger cities an efficient corps of men is maintained by the fire underwriters, who render service at fires in preventing water damage.

These corps are provided with one or more automobile wagons especially designed to carry covers and various appliances for cleaning up after fires and for the removal of water. The covers usually are 12 feet by 18 feet and consist of cotton duck of about 8 ounce per yard weight, variously treated with a paraffin compound or a linseed oil compound or coated with rubber. The present tendency is for ladder companies, and in some cases hose or engine companies, of the municipal fire department to be equipped with from one to four covers. This permits the excess apparatus and men responding to a fire, particularly in residential districts and where the fire is small, to render some salvage work by covering material on the floors below the fire.

72. HOSE AND COUPLINGS—Standard fire department hose is 2½ ins. inside diameter and is sold in 50-ft. lengths. Formerly all departments used **rubber hose**, composed of a rubber lining, backed by three to five plies or thicknesses of cotton duck and covered with a thin layer of rubber compound; this type of hose is still much used in large cities, where busy companies have no time to dry hose thoroughly and in the few departments that still use hose reels. The great majority of departments now use **cotton rubber-lined hose.** This consists of a rubber lining with one, two, or three cotton-fabric jackets drawn over it, the rubber being cemented to the innermost jacket. In both types of hose the rubber lining acts simply as water-proofing, the cotton duck or the fabric taking the strain of the water pressure and resisting the wear of dragging over cobbles, rough ground, and broken glass. The cotton-jacket hose must be dried after using, to prevent mildew and rot; when properly cared for the lining should last for about seven years, unless the jacket is cut or worn through.

73. Formerly the best grade of rubber, new Para, was used in making the rubber linings of hose but when the growth of the automobile industry created a great demand for rubber, at higher prices, methods were invented for utilizing inferior grades and for reworking old rubber. An extensive series of tests and analyses, conducted by the Underwriters' Laboratories, revealed the fact that much hose was being constructed of inferior mat‑rials, some linings containing only reworked rubber and little of that. Then the Laboratories, in collaboration with experienced hose makers and chemists, drew up specifications for fire hose, thus giving the purchaser a standard whereby he may be certain of securing reliable hose. A **label service** was also instituted, similar to that for other fire protective appliances, which assures the purchaser of labeled hose that it has been constructed under the supervision of the Underwriters' Laboratories, and in strict accordance with their specifications. The purchase of hose on specifications instead of by trademark or brand has become common. For the great quantities of hose used in the Army camps and Government shipyards, only labeled hose was purchased.

74. The 2½-in. hose is best adapted for regular use, but if **long lines** are laid or large streams required the 3-in. size is better. With a standard 1⅛-in. fire stream flowing the friction loss in good 2½-in. hose is fifteen pounds per 100 ft. Thus, with 800 ft. of 2½-in. hose 120 pounds' pressure is needed to overcome friction and forty-five for the nozzle pressure, so the engine must work at 165 to 170 pounds. If hose is attached to a hydrant, the pressure is limited probably to eighty or ninety pounds and larger hose or more lines, siamesed, must be used to produce a stiff stream. Three-inch hose will convey the same quantity of water over two and one-half times as far as 2½-in. hose, with the same friction loss; for a standard 1⅛-in. stream with 800 ft. of 3-in. hose only ninety-four pounds' pressure will be needed at the engine or hydrant. By laying two lines and siamesing into one near the nozzle, the friction loss may be still further reduced, or about one fourth the loss with a single line. In other terms, 108 pounds engine pressure will push a 250-gallon 1⅛-in. stream through 400 ft. of 2½-in. hose, or 1,000 ft. of 3-in. hose, or 1,500 ft. of 2½-in. hose siamesed. Three-inch hose is heavy and stiff and not adapted for ordinary use in buildings or on ladders, so the recent practice is to arrange the hose in wagons in two sections so that the 200 to 300 ft. first drawn off shall be 3-in. and the rest, which may have to be moved about, shall be 2½-in. The National Board has made the following recommendations: that each hose wagon shall carry at least 200 ft. of 3-in. hose for outside leads. For high-value districts, that eventually each wagon shall carry equal amounts of 2½ and 3-in. hose, in two sections.

75. A **complete extra shift** of hose should be provided for each company so that after a fire dry hose may be placed in the wagon and the wet hose hung up to dry. In case hose is burned or otherwise destroyed, or for large fires where wagons must come back to reload, the reserve hose is also needed. Investigation shows that the average hose lines in city fire department practice are somewhat over 400 ft. in length; therefore, to provide two average lines each wagon should carry about 1,000 ft. of hose. For wagons accompanying large engines able to pump over 800 gallons, or for outlying districts where long lines are common, 1,200 to 1,400 ft. are better, making three ordinary lines or one long line for places at a distance from hydrants. Hose if not used should be shifted on the wagon at least every two weeks, to prevent wildew and cracking of the lining.

76. For **drying hose**, racks, shelves, or towers are necessary. Some cities have one central hose station where all wet or damaged hose is cared for by detailed men and little or no spare hose is kept at fire stations, but this method is bad for outlying companies, as the wagons must leave their districts in order to shift hose. The best and most convenient arrangement for drying hose is the slanting rack room, built at side or end of station, as hose laid on racks is not strained and stretched. The front or lower door is at a convenient height for loading into wagons, the floor slopes upward to the second story at the rear and is covered with sheet metal for easy washing. A door at the back provides easy access. On one or both sides of the room are slatted or cross-barred racks or shelves for drying the hose after it is washed. In large cities space is at a premium and the additional lot width for a rack often cannot be obtained, so hose towers are used; these are generally high enough so that a 50-ft. length of hose when suspended by the coupling lugs will swing clear of the apparatus floor.

77. In **cold climates** hose towers are provided with steam coils or a heater, known as a salamander, to thaw and quickly dry frozen hose. In some old stations narrow shelves are placed in the cellar or apparatus room for the spare hose. This is not so bad for rubber hose but does not work well with cotton-jacketed hose, as the air cannot get at all parts of the jacket and it mildews. Some hose towers are so short that the hose must be hung doubled, either on a rope or over a grooved saddle; this is bad for the linings. Hose in towers should be hung with male end up; this avoids jamming the female swivel and bruising the male thread.

78. Hose couplings in use are of many different types and sizes; screw threads are mainly used; numerous varieties of snaps, locks, and clutches also in use are being gradually superseded by screw couplings. To secure uniformity interested organizations have combined to urge the use of the National Standard screw couplings of seven and one-half threads per inch and 3 1-16 ins. for outside diameter of male thread. At the great Chicago fire it was discovered that the diversity of couplings was a great hindrance to utilizing aid from neighboring cities and subsequent conflagrations have emphasized that discovery. The International Association of Fire Engineers early adopted the National Standard coupling, which will fit most hose and hydrants, and to which many of the odd sizes can be readily adapted.

79. A committee of the National Fire Protection Association was actively engaged from 1905 to 1917 in fostering the movement for standardization, but in the latter year this work was, by mutual agreement, taken over by the National Board of Fire Underwriters. A set of tools has been developed whereby couplings, which are not too far different in diameter or number of threads from the standard, can be converted into standard couplings. This process is now actively underway in 15 states under the guidance of fire marshals departments, fire chiefs associations and underwriting organizations. In the past two years more than 500 cities and towns have been standardized and indications are that progress in this direction should be rapid from this time on.

80. Where 2½ and 3-in. hose are in use it has been found a great convenience to equip the 3-in. hose with 2½-in. couplings, in order to eliminate delays from mislaid reducers and varying couplings. Contrary to general impression the use of smaller couplings does not appreciably affect the friction loss, so that for ordinary fire streams the difference in pressures from straight 3-in. hose or 3-in. hose with 2½-in. couplings is not noticeable. Therefore the National Board has recommended that both 2½ and 3-in. hose be equipped with 2½-in. National Standard couplings, properly beveled.

SEPARATE HIGH PRESSURE FIRE MAIN SYSTEMS

81. The high conflagration hazard in American cities, the great values involved and the effects of a conflagration on business and civic growth have been advanced as arguments in favor of providing the most effective known means of checking large fires. All that is required under existing weak building conditions in most cities is the right combination of circumstances to make a fire too large for the fire department to handle. It is in realization of such conditions that the larger American cities, and some of the smaller ones, where the expense of sufficiently improving the domestic water supply system is high, are installing separate systems of water mains for special high pressure fire service. The advantages of such a system may be summed up as follows:

82. A large number of powerful streams can be concentrated on a fire in much shorter time and with fewer men and less apparatus than with fire engines, and at the same time the protection of the rest of the city would not be weakened to the extent now necessary on third and fourth alarms from the district covered by the system. It will deliver its full capacity at any point in the district covered and at any desired pressure, and can sustain this pressure as long as wanted. It eliminates the confusion entailed in the operation of a large number of fire engines, tends to prevent the misunderstanding of orders and in every way simplifies operation. Above all it provides protection to the congested-value district even with a general alarm fire under headway in another part of the city and is the greatest insurance against conflagration, forming an effective barrier against fires starting outside the district and affording the most efficient check to fires in the district which might otherwise involve a number of large blocks. The tendency in all modern fire departments is to use large, penetrating streams, as these alone are effective on a fire well under way in the ordinary large-area building filled with combustible stock. Each large stream requires, under the most favorable circumstances, one first size or larger engine or two smaller ones, working up to full capacity, while one hydrant on the high pressure system can supply four or five such streams.

83. It is possible in some cities favorably located to obtain supply for such a system by gravity from some source sufficiently high to give 125 to 150 pounds' pressure, which with large mains to reduce friction loss will give an effective system. Other cities are obtaining partial service from lines of pipe laid from the waterfront and fed by fire boats; this has such serious disadvantages that most of these cities are contemplating the erection of a pumping station when money is available.

84. The system in the Borough of Manhattan, New York City, is the largest now in use. The main features are a gridironed system of underground pipes, 12 to 24 ins. in diameter, to which are connected two pumping stations taking water from the city mains and delivering into the high pressure system at pressures of 125 to 300 pounds. Each station is equipped with five centrifugal pumps, driven by direct-connected induction motors. Each pump was guaranteed to deliver 3,000 gallons of water per minute at 300 pounds' pressure and at the acceptance tests did deliver an average of 3,600 gallons per minute, a total of 36,000 gallons for both stations. The delivery is proportionately greater at lower pressures and reaches a total of about 50,000 gallons per minute at 200 pounds' pressure. Fresh water is used, as it causes less damage to stock in buildings than salt water, and also because it has less effect on the pipe of the system; however, the stations are located close to tide water and all necessary connections are made for the use of salt water in emergency. The precautions taken to insure the integrity of the pumping stations and the reliability of operation include: Pumping stations of fire-resistive construction throughout, protected against exposure fires and located outside the conflagration zone; power for operating the pumps supplied from five different power stations of the New York Edison Company, with duplicate sets of underground cables to each pumping station; duplicate mains from the pumping stations to the gridiron system, and automatic relief and pressure-regulating valves at each station. Pressure is not kept up at all times; when a fire alarm comes in from the district covered by the system the pumps are started and the pressure raised to 125 pounds. This takes less than one minute, so that the water is always ready before the fire department can lay a line of hose and connect to a hydrant.

85. Large post hydrants, to which four or five lines of hose may be attached, are the only connections through which water may be drawn from the system—there are no connections inside buildings to break and bleed the system. Each hydrant is capable of supplying at high pressure as much water as five ordinary fire engines of the first size.

86. A telephone system is provided, by means of which the officers in charge at a fire can communicate with the pumping stations from any location in the district covered. More pressure can be ordered at any time and is immediately available. As many of the pumps are operated as are necessary to maintain the desired pressure and this pressure can be sustained for any length of time.

87. The first sections of two double engine companies and the second sections of five now consist only of automobile hose wagons; otherwise all fire engines have been retained in service. They seldom attend fires in the high pressure district, however, as the fire engines do not report regularly to alarms. In case of any accident or unusual draft, causing

HIGH PRESSURE FIRE SERVICE SYSTEMS

(Corrected to June, 1922)

City.	Estimated Population, 1916.	Date of Installation.	Source of Pressure.	Gals. per Minute.	Max. Press., Lbs.	Lineal Ft. of Mains.	Sizes of Mains, Inches.	Number of Hydrants.	Total Cost of System.	Number of Acres.	Cost per Acre.
Atlantic City	57,806	Partly in service.	Connections to hotel pumps.	10,000 ±		To cover Board Walk District.					
Baltimore . . .	589,621	1912	Pumping station Steam pumps	13,000	250	46,700	10–30	226‡	$534,050*	230	2,300*
Boston.	756,476	1921	2 stations Elec. & steam turbine pumps	13,000 and fireboat	300	Distribution covers most of High Valve District					
Brooklyn. . . .	1,928,734	1908	2 pump. stations Elec. turb. pumps	32,000	300	. . . .	8–20	. . . . .	1,384,500	1,420	975
Buffalo	468,558	Being installed	Steam turbine centrifugal	9,000	300	. . . .	12–20	. . . . .	. . . .	. . . .	. . . .
Cincinnati . . .	415,000	1917	Gravity†	10,000	150	. . . . .	8–20	. . . .	. . . .	. . . .	. . . .
Cleveland . . .	674,073	1907	1 pump. station Elec. centrif. pumps	12,000	270	37,665	8–20	96	170,000*	338	500*
Coney Island	. . . .	1905–6	1 station Gas triplex pumps	3,600	150	. . . .	8–16	. . . . .	90,000	147	612
Detroit.	571,784	Being installed	Elec. centrifugal pumps	15,000 at 300 lbs.	300	57,000	8–20	193	. . . .	. . .	. . . .
Fitchburg . . .	41,781	. . . .	Gravity†	5,000	180	28,250	8–16	. . . .	50,000	346	144
Fort Worth. .	104,562	1910	1 station steam Emergency connection to domestic system	5,000	100 to 200	42,200	8–16	106	. . . .	245	. . . .
Jacksonville .	76,101	1911	1 station Elec. centrif. pumps	5,000	175 cent 192 actual	22,688	8–20	90	58,000	180	537
Lawrence. . . .	100,560	1906	Gravity†	3,000	134	10,200	10–12	39	. . . .	120	. . . .
Newark	408,894	1905	Gravity†	3,500	165	15,000	20–30	52	135,000	303	446
New York. . .	2,100,000	1908	2 stations	30,000	300	289,500	12–24	1,200	3,280,000 }	1,430	{ 2,300*
Manhattan . .			Elec turbine pumps						3,950,400 }		{ 2,763

IN CITIES OF THE UNITED STATES

City.	Estimated Population, 1916	Date of Installation	Source of Pressure.	Gals. per Minute.	Max. Press., Lbs.	Lineal Ft. of Mains.	Sizes of Mains, Inches.	Number of Hydrants.	Total Cost of System.	Number of Acres.	Cost per Acre.
Miami, Fla. .	32,000	1913	2 stations. Elec. cent. & steam fire pumps	5,500	175	7,450	8–16	29	....	136	....
Oakland.....	198,604	1910	1 station. Oil engines geared to turbine pumps	2,000	200	12,000	10–14	....	146,000	.....	....
Philadelphia.	1,709,518	1903	1 station. Gas triplex pumps	9,100	300	64,940	8–16	250	590,000* 700,000	512	1,150* 1,367
		1910	1 station. Gas triplex pumps	12,350	300	112,780	8–18	453	....	.....	....
Providence . .	254,960	1897	Gravity†	7,000	116	29,400	12–24	89	143,136	358	400
Rochester . . .	256,417	1874	2 stations. Elec. turb. and steam turb. pumps	9,000	140	102,960	4–20	.....	....	.....	....
San Francisco	463,516	1912	2 stations. steam turb. pumps also 10,000,000-gal. reservoir	32,000	300	508,000	10–20	.....	....	5,300	....
Toledo......	191,554	1917	1 station. Elec. centrifugal pumps	8,000	300	22,625	10–16	67	....	140	....
Toronto.....	215,000	1909	1 station. Elec. turb. pump.	8,333	300	40,000	8–20	146	500,000	287	1,742
Winnipeg....	110,000	1907–8	1 station. Gas Producer, gas, engine, triplex pumps	10,800	300	15,840	8–20	.....	650,000	275	2,364
Worcester...	163,314	....	Gravity†	5,000	165	100,320	8–30	.....	....	1,380	....

* Exclusive of pumping station and equipment.

† System consists of extension of pipes from High service into district covered by Low service.

‡ Flush hydrants with portable heads carried by each hose wagon.

reduction of pressure, a special signal will be sent over the fire alarm system and the engines will report.

88. The other high pressure systems in operation and in course of construction involve the same general features, differing according to local conditions, in capacity, in type of pumps, in motive power, and in features of the distribution system. In addition to centrifugal pumps and electric motors, reciprocating pumps and steam, gas and oil engines are in successful use; details of the systems now in use are given in the accompanying table. The most common pipe is extra heavy bell and spigot cast-iron, but welded steel with special joints is used in Baltimore, and both flanged jointed and universal jointed cast-iron in Philadelphia. The Baltimore system is provided with flush hydrants, with portable heads, each outlet of which has an independent pressure regulating valve. In some of the later systems mains on alternate streets are normally not connected, providing a "duplex" or double system covering the area protected; by this means protection can be maintained with a break in part of the system by using only the hydrants on the half of the system not affected.

89. Practical experience has shown that the following requirements should be met in the design of a separate high pressure fire system to insure good fire protection in districts it is to cover:

90. A fire-resistive pumping station, with all openings protected in an approved manner and removed from the zone of sweeping conflagrations. Station to be equipped with sufficient pumping units of moderate capacity to aggregate a total capacity of 20,000 gallons per minute (10,000 to 15,000 gallons in small cities) at 300 pounds pressure, taking suction from a reliable source and delivering into the gridiron system through well looped and gated discharge connections.

91. The distribution system to be connected with the pumping station through duplicate supply mains and to be so designed as to deliver the full capacity about any block within the area served without excessive loss of head; to contain no pipes less than 12 ins. in diameter, no dead ends and be connected at all intersections. Connections to be provided to the system so that fire boats may be used as auxiliary pumping stations in case of emergencies, and system to be provided with gate valves so placed that not more than 500 feet of pipe will have to be cut out at one time.

92. Hydrants to be of ample dimensions, with four independently gated hose outlets and connected to the mains through 8-in. gated connections; to be so distributed that the average area served by each shall not exceed 40,000 square feet.

MUNICIPAL FIRE ALARM SYSTEMS

93. Wherever community or municipal service is relied upon for fire extinguishment there should logically be some prompt and reliable means for notification of the location of the fire.

94. The primitive method of outcries from the discoverer of the fire or from a watch or police officer was succeeded by the ringing of a bell by a man stationed on a watch tower. In many small communities there are still hung on some corners locomotive tires which are struck a certain number of blows to indicate the location of the fire. This and the use of tower bells, whistles, and sirens, which can be arranged to sound a code signal, was the first step towards fire alarm service which would call firemen and apparatus directly to the scene of the fire.

95. The next step was to eliminate the waste of time in going some distance to this sounding instrument, and was accomplished by using the telegraph circuit to transmit a code signal from one or several points to the sounding device. This was the birth of the fire alarm telegraph system, and to the forefathers of the Gamewell Company is this advance due. The accepted fire alarm system in this country is still based on telegraph code signals, but many features assuring reliability have been perfected in the years that have passed.

96. It is not necessary to go into much detail as to the various requirements of a modern fire alarm system as they are all covered by the Regulations of the National Board of

Fire Underwriters on Municipal Fire Alarm Systems, which can be obtained and read by any one interested.

97. Some of the fundamentals are, in the order of the transmission of the alarm and not in the order of importance:

1st.—Boxes shall be so spaced and located as to be readily and quickly reached by anyone. Few American cities have all the boxes they need, and it is believed that at a not far distant time there will be a box in plain view to anyone going outside the door of the building.

2d.—Boxes must be so designed as to be reliable and positive, so that every time a box is pulled for a fire it will give its proper code signal at the fire stations. This has been done with the use of the succession box and of special features at headquarters, but further advances may be expected in this line as the years pass.

3d.—Circuits shall be such that they will not be put out of service readily. During the severe sleet and wind storm of the winter of 1922 nearly all of New England was without fire alarm service for periods ranging from hours to weeks, due to fallen poles, trees, and other things breaking the overhead lines. For this reason all circuits should be in lead cable underground, and fire alarm wires kept away from any which carry current of such high amperage as to introduce possibility of burnouts.

100. The municipal fire alarm system is primarily to furnish general protection to all buildings and, of course, must be in service during conflagrations or smaller fires. For that reason, it is unwise to run any of the circuits which serve street fire alarm boxes into buildings. Of course, they must enter fire stations and the headquarters building, but these should be of fire-resistive construction and the circuits so installed that there is little possibility of interruption. For other buildings and plants, if a separate circuit cannot be run direct to fire alarm headquarters, the boxes should be installed just inside of the building with arrangements made that the part of the circuit going into the building can be cut out and the street system maintained.

101. With the advent of the **telephone** and its very common use, this means of transmitting fire alarms became very general. In fact, some of the Western cities, notably, Kansas City, Missouri, and Wichita, Kansas, have depended entirely upon telephone fire alarm systems and have developed interdepartmental systems to a very high degree. There is no denying that the telephone, in many cases, is easier to reach by the person desiring to send in an alarm than would be a fire alarm box located a block away, and that the telephone gives an exact location of the fire, inasmuch as the person sending the alarm can tell, not only the street and house number, but also the position of the fire and its seriousness. In these respects, the telephone is all that is desirable, but there are other defects which outweigh the value of the telephone, most of which are outlined in the three requirements listed above. The sender of the alarm may be so excited as not to give the proper location or not to give it in an understandable manner or may not be able to speak English. There is a lack of accessibility of telephones at night and on Sundays and holidays in the high-value district, where the immediate sending of an alarm is essential. There is no assurance of continuity of service as the equipment, circuits, and other parts of the system are not designed with the degree of strength and reliability that are necessary for fire alarm service. The possibility of strikes is also an element of considerable moment. These and other conditions make it unwise to depend entirely upon telephones for fire alarm service.

102. A fire alarm telegraph system is of particular value during conflagrations. At the time of any large fire, the telephone service breaks down entirely so far as the transmission of alarms is concerned. This is because there is no method by which persons desiring to transmit a fire alarm can make it known so that they receive service in advance of those making other inquiries. The telephone switchboard becomes a mass of lights due to the innumerable calls for service by persons wishing to communicate with friends or to get information or to advise of additional fires.

103. In recent years, the question has arisen as to the possible adaptation of **radio** or **wireless signaling** in connection with fire alarm service. With the early perfection of the radio telephone, various fire chiefs equipped their cars with receiving sets and tried that means of keeping in touch with fire alarm service during fires and during inspection work. Some manufacturers have experimented with boxes which could transmit radio signals which would be received at the fire station. Inasmuch as code signals consisting of taps or blows are considered as the best means of definitely receiving alarms of fire, it will be possible to design a radio system of a wave length such that there will be little chance of interference, but it is questionable whether the complications introduced and other features affecting reliability will not far outweigh any gain which may be apparent from the use of radio sending and receiving. There can be no doubt that radio signaling for fire alarm purposes will be made use of in connection with fires on boats and possibly in connection with fires in isolated sections, but as such it will be, as is the telephone service at present, only an auxiliary to the fire alarm telegraph system in transmitting and receiving alarms of fire.

CHAPTER 26

WATER SUPPLY FOR PRIVATE PROTECTION

1. Hydrant, automatic and open sprinkler, and standpipe protection depend for their efficiency on reliable water supplies of ample capacity and pressure. The first problem in laying out fire protection for a plant, therefore, is to secure a suitable water supply.

2. Before taking up details of the various kinds of supplies which may be available, there are certain general features which merit earnest consideration.

FLOWING VS. STATIC PRESSURE.

3. The only useful test of the value of a water supply is its ability to deliver the desired number of gallons per minute at an effective pressure. Static pressure means little. Small pipe systems, badly corroded pipes, or long dead end runs of fair size pipe of apparent value are at once shown deficient by a flowing test from an open hydrant butt. In one instance, an important car barn depended for hose protection on a city connection carrying a 70-lb. static pressure. Under open butt test, a gage graduated by pounds would not register. In the case of a pretentious country estate, a 140-lb. static pressure dropped to 10 lbs. when 270 gals. per minute were taken from the end hydrant on system.

4. See section on "Method of Testing Water Supplies" for methods of determining the capacity of a water works system at various pressures.

NECESSARY PRESSURES.

5. The higher the pressure, the more effective are sprinklers and hose streams, except that very high pressures are difficult to handle safely and are likely to cause trouble with underground mains.

6. Fire pumps are generally set to operate at not over 125 lbs., and this pressure is sufficient for all but the highest buildings.

7. Pressure tanks, placed usually on the top floor or the roof of sprinklered buildings, are generally under 75 lbs. initial pressure, which drops to 15 lbs. at the tank when all water is discharged.

8. Gravity tank trestles in modern plants range from 75 ft. to 150 ft. high, equal to 32.5 lbs. to 65 lbs. at the ground level when tank is empty, and about 10 lbs. more when tank is full.

9. Pressures in city water mains range from under 20 lbs. during the heavy draft periods in some cities to around 150 lbs. in others. See Chapter 39, on Conflagration Hazard and Protection, for pressures in larger cities.

10. For automatic sprinklers, the primary or automatic supply should preferably exert a static pressure of not less than 25 lbs. on the upper line of sprinklers, although with gravity tanks it is common practice to require a minimum elevation of the bottom of the tank of 25 ft. above the upper line of sprinklers, which, with the ordinary sizes of tanks, produces when tank is full from 15 to 20 lbs. static pressure on the top line.

11. The flowing pressure at the top line, with a flow of water sufficient to feed the number of sprinklers likely to be opened in a single fire, should not be less than 10 lbs. per sq. in. The rules call for 12 lbs. static at the top line with 500 gallons flowing at a hydrant, where there are not over 200 heads in one fire area.

12. For outside hose protection, any flowing pressure of less than 75 lbs., if plant has buildings up to four stories high, cannot be considered good. 60 lbs. might answer with hydrants so laid out that hose lines need never exceed 150 ft. A 50 lbs. flowing pressure has value with one- and two-story buildings.

13. It is highly desirable always to bear in mind probable increases in size of plant, magnitude of fire areas, and the likelihood that a growing plant will increase the height of its newer buildings.

NECESSARY CAPACITIES.

14. After ascertaining the necessary flowing pressure to afford efficient protection, the problem of the necessary available gallons per minute requires consideration.

Automatic Sprinklers.

15. The insurance requirements for capacity of water supply for automatic sprinklers vary greatly. Some insurance organizations take account of the number of sprinklers on one floor in a single fire section, but the area really has little or no bearing on the amount of water needed; other features are of far greater importance. For instance, character of construction, concealed spaces, floor openings, height of ceiling, pitch of roofs, and obstruction from timbers all have a bearing on the number of sprinklers likely to operate in case of fire. Occupancy hazards and combustibility of contents are of great importance; also possibility of fire reaching the buildings from other property.

16. All of these conditions should be taken into consideration in determining the necessary capacity for any water supply. Using the gravity tank as an example, a 10,000-gal. tank would be ample for a one-story brick, mill constructed machine shop even if of large area, while a relativeley small storehouse filled with bales of cotton might need several times as large a tank.

17. When feeding sprinklers only, 10,000 gals. is generally considered a minimum for a gravity tank, and 25,000 a maximum, and, in deciding as between these limits, the smaller tanks can be considered satisfactory when the conditions are such that only a few sprinklers (not over 10 or 15) are likely to operate, while the larger tanks are desirable if 15 to 25 or more sprinklers are likely to operate. When feeding sprinklers and hose, 30,000 gals. is the minimum permitted by the rules.

18. For pressure tanks the minimum capacity is 4,500 gals., i. e., 3,000 gals. of water. The larger sizes such as 6,000 and 9,000-gal. tanks are frequently used, and here again the capacity should be determined in accordance with the conditions.

19. When pumps are for sprinklers only, the size and volume of water required also depends on construction and occupancy, but as most pumps are used also for outside or inside hose, both their size and their water supply are considerably larger than would be needed for sprinklers alone. The smallest Underwriter's pump is 500 gals. per minute, and with not less than 30,000 gals. of water to draw from should be ample for most properties if used for sprinklers only. A standard hose stream of 250 gals. per minute is the equivalent of from 15 to 20 sprinklers.

20. The insurance organization having jurisdiction should always be consulted as regards capacity of water supply, for as already mentioned rules and methods vary considerably in different jurisdictions. The automatic sprinkler rules covering water supplies are as follows:

SECTION 1—WATER SUPPLIES.

61. Double Supply.—For a standard equipment two independent supplies are required. At least one should be automatic and one capable of furnishing water under heavy pressure. The choice of water supplies for each equipment should be determined by the Inspection Department having jurisdiction.

62. Public Water (except high pressure systems; also applicable to private reservoir and standpipe systems).—One or more connections from a reliable public water system of good pressure and adequate capacity furnishes an ideal "primary supply." A high static water pressure should not, however, be a criterion by which the efficiency of the supply is determined. The supply from city main should not be considered standard unless a hydrant test of the main capacity with 500 gallons per minute flowing indicates sufficient residual underground pressure to give at least 12 pounds under the roof; this requirement of flow is the minimum for equipments having 200 heads or less in one fire area; larger areas will require additional flow in gallons per minute.

Street mains should be of ample size, in no case smaller than 6 inches. Dead end mains should be avoided if possible by arranging main to be fed both ways. No pressure regulating valve should be used in water supply for sprinklers, except by special permission of Inspection Department having jurisdiction, and where meters are used they should be of a standard type.

Where connections are made from public waterworks systems, it is often desirable to have double check valves. Only check valves of special design and standardized for this purpose should be used.

See also Section E, Rule 26, page 541. (See also page 324.)

Connections to public waterworks systems should, where feasible, be controlled by post indicator valves of a standard type and located not less than 40 feet from the buildings protected; or, if this cannot be done, placed where they will be readily accessible in case of fire and not liable to injury. See Rules 26, 27, 29, 31, 32, 92 and 103. Where post indicator valves cannot readily be used, as in a city block, underground gates should conform to the above as far as possible and their locations and directions to open be plainly marked on the buildings.

Connections for domestic or standpipe use over 2 inches in size should conform to the above

All post indicator valves should be plainly marked with the service they control.

63. Pumps.—A well-located fire pump is, under most conditions, the most satisfactory source of the "secondary supply," as with ample water supply it is capable of maintaining a high pressure over a long period of time.

The capacity of the pumping plant, the kind of pump and its source of water supply, should be determined by conditions, and should be the subject of special consideration in each case by the Inspection Department having jurisdiction. The capacity of pump should never be less than 500 gallons per minute when it supplies sprinklers only, and not less than 750 gallons when it supplies hydrants also.

For the construction, installation and maintenance of Steam, Rotary, Centrifugal and Gasoline Fire Pumps, see special pamphlets issued by the National Board of Fire Underwriters.

64. Tanks.—Gravity.—The capacity and elevation should be determined by the Inspection Department having jurisdiction; but where a tank is also drawn upon for hose streams it should not be of less than 30,000 gallons capacity, and should preferably be installed with the bottom not less than 75 feet above the yard level. In any case the bottom of the tank should be at least 20 feet above the highest sprinklers.

Tanks.—Pressure.—Capacity of tank should be specified by the Inspection Department having jurisdiction, but should be not less than 4,500 gallons total capacity, except by special permission, and tank should not be located below the upper story of building, and should be used as a supply to automatic sprinklers and hand hose only. (See page 387.)

For the construction, installation and maintenance of Tanks and Supports, see special pamphlet issued by the National Board of Fire Underwriters.

65. Penstocks or Flumes.—Where connections are made from these, either as a direct supply to auomatic sprinklers or as a suction for fire pumps, they should be arranged to avoid mud and sediment. Connection should also be provided with double removable screens installed to the requirements of the Inspection Department having jurisdiction. Where connections are made from rivers or lakes they should be provided with double removable screens similar to those for pump suction.

66. Size of Connection.—Connection from water supply or main pipe system to sprinkler riser should be equal to or larger in size than the riser. Connections for domestic use should not be taken from the fire system. See also Section E, Rule 26, and Underground Pipes, Section M.

Outside Hose Streams.

21. The basis of calculation is the standard stream of 250 gals. per minute, which amount of water is discharged through 1⅛-in. smooth nozzle at 45-lbs. nozzle pressure. Such a stream has an effective range of about 70 ft. vertically and 67 ft. horizontally with moderate wind. See Table 8, on page 608.

22. Few plants are small enough to require less than two streams, and the smallest Underwriters' fire pump is 500 gals. capacity. Four streams is the average number of streams desirable for a plant of fair size, and important plants often have water available for 6, 8, 10, and even over 20 streams. A recent fire in an oil building of only moderate size required 10 hours of uninterrupted service of 16 hydrant streams.

Open Sprinklers.

23. Open (outside) sprinklers have been more commonly installed on brick buildings, with a single sprinkler at each window. Special sprinklers are used for proper distribution, generally with ¼″ to ⅜″ orifice. The average discharge per sprinkler should not exceed ten gallons. Where over 30 or 40 sprinklers are desired, the pipe system is usually divided into several sections, not all of which may be turned on at time of fire.

24. 25 to 30 heads is the equivalent of one good hose stream, and this amount of water must be available at sufficient pressure to give not less than 10 lbs. working pressure on the upper line of sprinklers with all sprinklers operating. With large city mains and plenty of water, centrifugal pumps can be often used to advantage. Such a pump of 1,500 gallons capacity should properly feed 150 or more open sprinklers. Gravity or pressure tanks are not proper or satisfactory supplies for open sprinklers because of limited amount of water. See Chapter 34 for further and detailed information on this subject.

TIME AVAILABLE.

25. Obviously, unlimited supply as to time is most desirable, and water works connections, or pumps drafting from rivers, brooks, or exceedingly large reservoirs are ideal from this standpoint.

26. Gravity tanks feeding sprinklers only must, as stated previously, have a capacity sufficient to meet the Underwriters' requirements.

27. If feeding hydrants also, if only temporarily until pump can be started, the tank capacity can properly be increased at least 10,000 gals. over the sprinkler needs. For a combination service, the minimum tank capacity should be 30,000 gals. If tank is to feed both automatic sprinklers and hydrants for any length of time, the capacity should be increased at least 25,000 gals. over sprinkler requirements, equal for two standard fire streams for about one hour.

28. Pump reservoirs are usually wisely provided to supply rated capacity of pump for not less than two hours; although the Underwriters will sometimes only require capacity for one hour.

AVAILABLE SUPPLIES.

29. The types of water supply available for private plant use are limited to the following:

a—Connections from water works mains.

b—Private reservoirs.
c—Gravity tanks.
d—Fire pumps of duplex steam, centrifugal, or rotary types.
e—Pressure tanks.
f—Connections from private mains of other plants.
g—Fire department connections, fed by city steamers or by city hose lines.

30. The order approximately indicates their relative desirability.

31. As a primary supply for automatic sprinklers, the fire protection engineer generally prefers the following in the order given:

a—Water works connection.
b—Private reservoir.
c—Gravity tank.
d—Pressure tank.
e—Automatic pump.

32. Where the water supply is for hydrant service, the above order applies, except that a non-automatic pump generally is preferable to a gravity tank, unless it is very large and exerts unusually high pressure.

33. A private reservoir of large capacity and exerting effective fire pressure is usually found only where water works connections are not available. In the following it is assumed that one or the other only is available, although in plants of great importance both may be found.

EFFICIENCY OF PRIMARY WATER SUPPLIES
(For Automatic Sprinkler Systems)
N. F. P. A. Tables 1910–1922

Primary Water Supply.	No. of Fires.	Percent. of Fires.	Av. No. of Sprinklers Opened.
Waterworks	9100	54.4	8.7
Gravity Tanks	3581	21.4	9.4
Pressure Tanks	2988	17.9	4.2
Pumps	875	5.2	9.6
No Data	178	1.1	19.8
Totals	16722	100.0	

Note: The greater efficiency of pressure tanks is due to higher initial pressure and to use frequently in less hazardous occupancies.

34. As a secondary supply to a water works connection or private reservoir, the pump (not automatic) or gravity tank are favored.

35. As a secondary supply to a gravity tank the pump is almost always best. A water works connection or private reservoir giving lower pressure than gravity tank must be almost as good in order to warrant its use as a secondary supply.

36. The pressure tank is almost always backed up by a gravity tank, and in very important plants a pump constitutes the third supply.

37. Automatic pumps are generally used only because water works, private reservoir, or gravity tank supplies are too weak for primary purposes.

38. Connections to other plant fire systems are very desirable.

39. Para. 33 shows the data gathered by the National Fire Protection Association as to primary water supplies. The percent of fires under each class is not nearly as important as the reliability, initial pressure, and number of heads opened. The reliability grading of the N. F. P. A. is water works connections, gravity tanks, pressure tanks, and automatic pumps, in the order named.

METHOD OF TESTING WATER SUPPLIES.

40. Desirable Equipment. The inspector who travels from city to city, and who desires without delay to be able to test any city or private hydrant independently of any locally secured equipment, must employ a hydrant connection in principle similar to that shown in Fig. 30. The swivel crossbar, after being pushed edgewise into the hydrant nipple, is squared away at right-angles, as shown in cut, wing nut runs brass plate and gasket against the edge of the hydrant nipple, and pressure is carried through hollow stem to gage. This design was developed by the Underwriters' Association of the Middle Department and has had years of successful field use.

41. If a city or plant play pipe is available, a tapered rubber plug fastened to a small pipe with lock nuts will answer the same purpose as the more complicated and heavier device.

42. If a sufficiently long stay is made at a plant, a hydrant

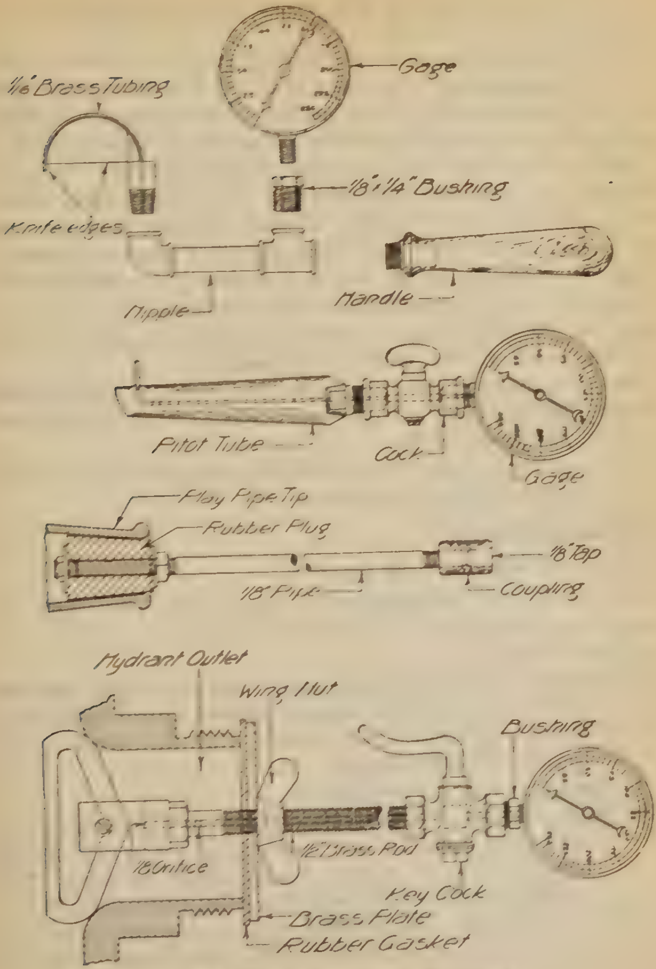


Fig. 38. Hydrant Testing Apparatus

cap can be drilled and tapped to enable a more direct attachment to hydrant.

43. These three methods of attaching gages to hydrants enable the static pressure to be obtained, readings to be taken at certain hydrants while water is drawn off from other points, or readings to be taken at the same hydrant if it has two or more outlets.

44. A Pitot tube for indicating flowing pressures is indispensable. On a 2-way hydrant it may not be needed, but with a 1-way hydrant and at nozzles of hose streams it is the only device that can be used. Two forms of Pitot tubes are shown.

45. The inspector's gage is best graduated by pounds from 0 to 200 lbs. An accurate, and correspondingly expensive, test gage is desirable, but not essential, especially if gages are periodically tested on dead weight gage tester.

46. A ⅛-in. pipe thread on gages and a ¼-in. × ⅛-in. bushing enables approximately all conditions likely to be met in the field to be handled successfully.

47. Two gages, one for hydrant or pump duty and one for nozzle use, are a great convenience.

COMMON TESTS.

Capacity of Water Works Systems.

48. An effective test procedure on one or more street hydrants near connection to plant is as follows:

a—Static test.

b—Flowing test with Underwriters' play pipe, with standard 1⅛-in. tip in place, screwed directly to the hydrant.

c—Flowing test with Underwriters' play pipe with 1¾-in. orifice (tip screwed off).

d—Open butt test at same hydrant.

e—If pressure drop is not considerable under open butt test, two open butts on one hydrant, or preferably one on each of two or more hydrants should be used. This method requires no hose and is quick and reliable.

49. The following gives test data that was secured under such conditions, the gallons discharged being taken from tables on pages 698 and 712.

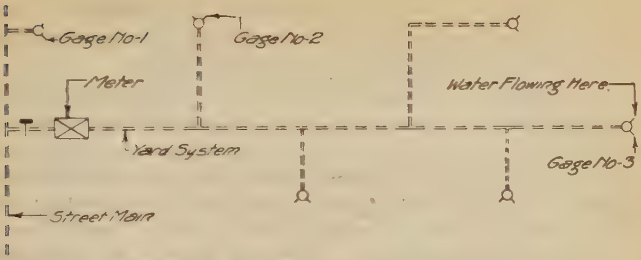


FIG. 39. METHOD OF TESTING CITY WATER SUPPLY TO PRIVATE HYDRANT SYSTEM

TEST OF STREET AND YARD HYDRANTS ON CITY WATER SUPPLY. (No Hose Used.)

Hydrant Used.	Source of Supply.	Diam. of Nozzle.	Hydrant Pressure.	Gals. per Min.
Jared St.	8″, Jared St. only	Static	95	0
" "	" " " "	1″	80	264
" "	" " " "	$1\frac{11}{16}$″	49	590
" "	" " " "	$2\frac{1}{2}$″ op. bott.	22	811
Brady St.	8″, Brady St. only	Static	83	0
" "	" " " "	1″	77	259
" "	" " " "	$1\frac{11}{16}$″	58	641
" "	" " " "	$2\frac{7}{16}$″ op. bott.	35	740
Shaffer Ave.	Both Jared and Brady Sts.	Static	95	0
" "	" " " " "	1″	83	269
" "	" " " " "	$1\frac{11}{16}$″	60	653
" "	" " " " "	$2\frac{1}{2}$″ op. bott.	33	964
Yard near planing mill	4″ metered yard connection	Static	95	0
" " " "	" " " "	1″	65	238
" " " "	" " " "	$1\frac{11}{16}$″	28	448
" " " "	" " " "	$2\frac{1}{2}$″ op, bott.	11	603

50. The character of the hydrant construction and the exact size of nipples is important in connection with open butt tests. See Table 18, page 712.

51. If no facilities for securing static pressure exist, the use of a tip smaller than the 1⅛-in. (smaller tips sometimes being available), will give approximately the static pressure.

Capacity of Plant Systems Fed by Water Works Connections.

52. The diagram shown in Fig. 39 illustrates a good arrangement for making a test of this kind.

53. Gage No. 1 shows street pressure, and should, for gallons discharged at far end of system, check data secured by street hydrant tests, if such tests have been made.

54. Gage No. 2, on branch line as close to meter as possible, will show flowing pressure in main at point where branch is taken off.

55. The difference in pressure equals the loss in meter and in pipe. The latter can be calculated from Table 1, page 686, and the meter friction checked against Table 5, page 691, to see if it is unusually high. Meters, of course, are undesirable in fire systems, unless of the fire service type, and are a frequent cause of enormous pressure drops.

56. Gage No. 3 gives readings at points where water is drawn off. The difference in pressure between gages No. 2 and No. 3 equals pipe friction or pipe and hose friction. This also must be checked against tables to see if conditions are unusual. See Chap. 41, The Tables and How to Use Them, for explanatory data regarding tests.

What Tests May Show.

57. The annals of fire prevention Bureaus abound with important, and not infrequently startling, facts which tests have developed. It is imperative to test a water supply system if any valuable opinion on its condition is to be given.

58. Furthermore, a system once tested cannot be expected to remain the same for any length of time. Valves closed in whole or in part, sediment or obstructions in mains, and pressure drop because of increased consumption, are among the reasons that make periodic *flowing* tests necessary.

59. Shortcomings which tests have detected include:

a—Water works connection gate valve closed, never having been opened.

b—Water works connection never made to city main.

c—Fire pump out of commission altogether or in part because of broken pipes, missing or leaking pump valves, blocked suctions, and insufficient steam supply.

d—Frozen tanks and drop pipes.

e—Mains entirely clogged with mud.

f—Mains with seriously reduced areas because of hard deposits on inside.
g—Serious leakage of underground system.
h—Mains smaller than indicated by plans.
i—Entirely or partly closed valves due to carelessness or ignorance of which way to turn.
j—Check valves pointing in wrong direction.
k—Leaky check valves, wasting higher pressure water.
l—Clogged or broken meters or clogged fish traps protecting them.
m—Existence of meters and valves not known.
n—Frozen underground mains and valves.
o—Inoperative hydrants.

Graphic Presentation of Test Data.

60. The advantage of graphic presentation of results in addition to tabulation of facts secured has been often demonstrated. If a reasonable number of points on a curve are secured, it is fair to assume that for intermediate points pressures and capacity will be as indicated by curve drawn through known points.

WATER WORKS SYSTEMS

61. If available and if suitable as to pressure and capacity, a connection to a water works system affords the best and usually the cheapest source of water for private fire protection. Under particularly favorable conditions such a supply may alone be sufficient for plant protection. See preceding sections regarding necessary pressures, capacities, and methods of tests. Practical suggestions in connection with securing water works connections include:

a—The need of ascertaining in advance the annual cost of a connection. City systems generally permit separate fire connection without an annual rental charge, although the cost of a 6-in. fire service meter in pit, where such meter is required, will be several hundred dollars. Private water companies generally charge according to size of connections, and a short 6-in. connection between a large street main and an 8-in. yard main will introduce very little additional friction and probably save considerable money as compared to an 8-in. connection.

b—Generally speaking, a 6-in. detector meter is large enough for 8-in. and possibly even 10-in. fire connections. The friction losses in a short 6-in. connection with tapered reducers at each end is so small that the saving resulting from not purchasing the much more expensive larger meter is usually warranted.

c—Even if the nearest adequate sized water works main is some distance away, it is frequently good business policy to extend it to a plant, particularly if the city or nearby plants will share the expense, as is occasionally the case when general hydrant protection becomes available or other plants desire private fire connections.

The extended street main becomes the property of the city or the water company and these look after upkeep. The cost to the plant, therefore, is only interest on the investment. Depreciation and upkeep on tanks or fire pumps, needed if water works connection cannot be secured, will probably be 6 to 8 per cent. per year.

d—To secure a private fire connection without charge necessitates having all domestic service on a separate metered system. Such separation of systems is highly desirable for the reasons listed below:

1—Reduces formation of sediment or corrosion in important fire mains.

2—Reduces possibility of interruption of fire service under ordinary conditions, because less carefully laid domestic connections give trouble, and new connections frequently have to be made.

3—Materially reduces risk of breakage of domestic connections at time of fire pressure.

4—Eliminates increased domestic consumption caused by raising pressure, at which time entire supply is secured from fire pump or other fire supply source.

62. Section I of the Sprinkler Rules requires that there shall be two independent supplies for a standard sprinkler equipment. At least one of these supplies must be automatic and one be capable of furnishing water under heavy pressure.

63. It is evident that a public water works system fulfills the requirement of being automatic, and the rules for this particular supply state that it should give not less than 25 pounds static pressure at all times of the day and at the highest line of sprinklers. This may be considered to explain what is meant by heavy pressure; but for best service it should be modified to the extent of maintaining approximately this pressure with water flowing through the number of sprinklers which are liable to be opened by fire at any one time. The rules state that, with sprinklers open, ten pounds on top sprinklers is satisfactory, but this could hardly be considered a heavy pressure supply and it would be more conservative to state that twenty to twenty-five pounds should be maintained on the top line, even with twenty-five to forty sprinklers operating. This would generally mean a street main of at least eight inches in diameter and a static pressure on top line of thirty to forty pounds. It is also important that street main be fed both ways to minimize interruptions during repairs, and with larger mains close by. Furthermore, such a supply should also be ample for hydrants located on the same street mains, otherwise the use of these hydrants at time of fire might materially reduce the pressure.

NEED OF TESTS.

64. The ability of a water works system to maintain pressure may generally be determined by using hose streams attached to hydrants, and a safe minimum requirement would be the maintenance of 20 to 25 lbs. pressure at the top line of sprinklers with two 1⅛-in. hose streams in service.

ONE-WAY SUPPLIES.

65. The fact that a satisfactory water works supply complies with both essential features of a proper water supply to sprinklers, namely, it is automatic and may furnish an adequate supply of water under heavy pressure, has naturally brought about discussions as to the necessity of a second independent water supply. In other words, is it reasonable to require another supply where the water works system is ample, both as to volume and pressure? It is evident that practically the only need of another supply would be the possibility of such a water works supply being temporarily out of service and in large cities the chances of such a contingency are undoubtedly very small. Furthermore, the expense of a second supply for small city plants is of material importance when compared to the cost of the sprinkler system as a whole, and it is quite possible that many property owners are deterred from installing sprinklers because of this additional cost. Frequently the cost of providing a gravity tank for an old structure will be as high as the entire cost of interior sprinkler equipment.

66. While therefore it cannot be gainsaid that the ideal equipment should have two supplies, it would appear that this standard is quite nearly approximated by sprinklers supplied by water works system which furnishes adequate pressure and volume, especially if there are connections to mains in two streets, and system so valved that interruption of plant supply is reduced to a minimum.

CHECK VALVES.

68. When a public water service is connected to a private fire system, it is desirable that the connection be so arranged that the water from the private system cannot flow back into the street mains, and to accomplish this it has been the practice to install a check valve in the connection. In order to increase the reliability of this arrangement, special check valves have been designed under specifications prepared by the Associated Factory Mutual Fire Insurance Companies, known as "Special Type F. M." These valves have bronze working parts, large clearances, and rubber-faced clappers. The covers of the valves are quickly removable and the clappers can be swung out of the bonnets to permit of ready inspection and cleaning. The valves are very efficient in operation, being designed to resist corrosion and to prevent disarrangement of the parts. Once a year the check valves should be inspected and the interior thoroughly cleaned. To facilitate removing check-valve bonnets, these may be packed with ⅛" sheet rubber packing, faced with machine oil and graphite and the bolts greased with heavy oil and graphite.

69. Further to increase the efficiency of the arrangement, two of these valves are connected in series, and in order that the check valves shall be readily accessible for inspection and test they are installed in a pit. See page 389 for data regarding pits. The scheme shown in Fig. 40 is that advocated by the Mutuals as giving double protection against leakage past a check valve and permitting ready test of the tightness of checks. Method of testing is as follows:

a—Open test valve D to blow out any sediment that may have accumulated in test valve or connecting pipe, and then close.

b—Close gate M and open test valve D. If pressure falls at gage A and pressure at gage B holds after decreasing slightly, check F is tight.

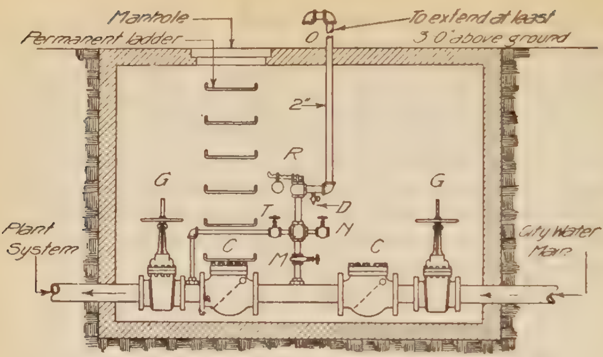
c—While test valve D remains open and pressure at gage A stands at zero, open test valve E. If pressure at gage B falls to zero and flow from test valve E ceases, check G is tight.

Caution—Immediately at close of test see that gates M and N are open. It is important that the protection be promptly restored.

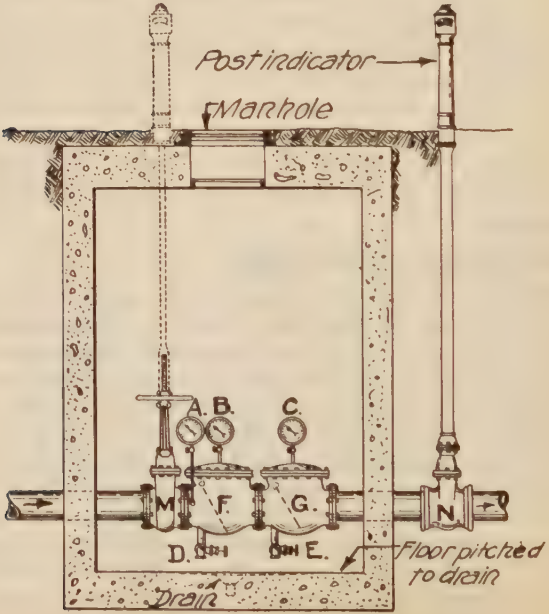
POLLUTION PREVENTION.

70. Connections from water works mains to fire systems having pumps drafting from rivers or other sources of impure water are often refused because of the dangers of pollution of the city's drinking water supply through the leakage of impure water past a single check valve. The plan described in Par. 69 and illustrated in Fig. 40 gives a large measure of protection vs. pollution. Fig. 40 shows also an automatic means of protection, operating as follows:

a—G and G are valves controlling the two water supplies, one pure and one polluted or likely to be, and are necessary to enable checks and relief valve to be repaired and cleaned without shutting down system. Either valve could be outside the pit and provided with an indicator post.



Automatic Pollution Prevention



Factory Mutual Double Check Valve Fire Service Connection

FIG. 40. METHOD OF PREVENTING POLLUTION

b—C and C are swing check valves of the best possible type as regards tightness and reliability of operation.

c—R is weighted type (preferably) relief valve about 2 ins. in size, set about 10 lbs. higher than maximum pressure the pure water supply is likely to carry.

d—T is ¾-in. test valve. It is used to put higher pressure on the relief valve and give it an actual test. During such test M is, of course, closed. Normally it is open.

e—N is a valved connection for a pressure gage, which may be permanently installed or brought by the inspector.

f—D is a drain valve, normally open, to protect riser O against freezing. This riser should extend at least 3 ft. above the ground so as not to constitute a tripping hazard.

71. Ordinarily, with one cneck valve in a connection, leakage owing to regularly or temporarily higher pressure on impure side is likely to take place, but with the automatic scheme shown above, the pollution danger approaches zero, because if one check leaks, the leakage will waste by relief valve set only 10 lbs. higher than the pure supply, rather than drive back through the second check. The likelihood of both leaking at the same time under a differential pressure of 10 lbs. is exceedingly small.

72. The relief valve discharge pipe continued above the pit is an automatic indicator of check valve leakage or of improper setting of valve R during non-freezing weather when D can be kept closed.

73. Both of the plans for pollution prevention shown in Fig. 40 are considered reasonably safe, but should only be installed after specific approval of the authorities.

METERS FOR FIRE SERVICE

By E. V. FRENCH*

74. Meters of the ordinary commercial types have always been objected to on connections from public water supplies to private fire systems, and their use has never been approved by fire protection engineers. The desire for them by water works officials in some communities has been due to two main reasons: first, because there are connections to supply water for other uses from the fire pipes, generally due to an old agreement, which may now be outgrown, and second, because of the fear that water may be taken from the fire system for other than fire purposes without payment.

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* President, Arkwright Mutual Fire Insurance Company.

75. In the earlier days of water works such other connections were often permitted, and this practice still prevails in many places, a flat rate being charged for what is estimated as the probable amount of water to be used. Under these conditions, some use of water from the fire system has been expected. In later years, however, many water supplies are being filtered, while the increase in the use of water has necessitated large expenditures for new supplies. This has resulted in a greatly increased effort to prevent waste and to get a full return for all water used, and consequently a demand for meters.

76. Sprinkler rules, Section I, provide that no water supply for sprinklers may pass through a meter or pressure regulating valve except by consent of the Underwriters having jurisdiction.

77. From the fire protection standpoint, the ordinary types of meters in common use are objectionable for the following reasons:

a—All of them obstruct the flow of water to some extent, and many types seriously reduce the pressure with the large flows required at time of fire, due to the friction of the water passing through the meter.

b—There is always a possibility with the ordinary types of disc and piston meters that an excessive draft will break some of the internal parts, block the moving members, and so choke the passages as to largely cut off the flow of water. Such blocking may also occur in other ways.

c—The fish traps, or strainers, usually used with meters, lessen the danger of breakage and blocking, but are themselves liable to become clogged by pipe scales, leaves, pieces of hemp, and similar refuse which is almost sure to be washed along by the high velocities of fire drafts, though with ordinary flows this material may lie on the bottom of the pipe. Such choking may easily be carried to the point where it will largely reduce the flow of water. These fish traps, therefore, make the "current" types of meters objectionable, even though in some meters of this type the friction loss due to the meter itself is quite small.

d—Necessary occasional internal inspection or removal of fire meters may interfere with continuous service. This is a strong argument for a by pass around the meter.

78. Table 5, on page 691, shows the friction losses for 6-in. and a few other sizes of the most common types of meters now on the market, and makes clear at a glance how serious is the friction loss caused by some types of meters.

METHODS OF PROTECTING PUBLIC SUPPLIES

79. The best means at present available for insuring the proper use of private fire systems, and protecting the interests of municipal water departments or private water companies, are as follows:

a—Have the fire piping laid out in a simple manner, so that it can be readily inspected. Supply the water for factory purposes by a separate system of pipes, so that there will be absolutely no connections from the fire system except to fire apparatus Then have a clear understanding that water is not to be drawn from the fire system except in case of fire, or for such occasional testing as may be agreed upon. In many places where there is cooperation between the owners of protected property and the water works officials, this arrangement will cover all the needs, and there will be no danger of any considerable amount of water ever being improperly used from the fire system.

b—If, however, it is felt that there must be some further guard to prevent irresponsible employes occasionally drawing water from a hydrant for some special purpose, and doing it against orders, simply because it is more convenient than to draw it from the proper source, it is entirely feasible to seal all hydrants and sprinkler drain valves, providing a penalty for broken seals. This plan was developed in New Bedford by Mr. R. C. P. Coggeshall, Superintendent of the Water Department, and, under regular supervision by men from the Water Department, has given good results.

c—Where some constant watch for a fire service is considered absolutely necessary, the following method may be used: First, cut off any connections which may exist on the fire system through which the water is being used for ordinary purposes, except perhaps a few small ones, the total draught through which would never exceed about 100 gallons per minute. This is desirable outside of the meter question in all ordinary cases, in order to prevent the waste of water from the fire pump through such connections in case of fire. Then put some form of detector on each fire service connection. The available types are discussed in the following sections:

FACTORY MUTUAL METERS.

80. The Associated Factory Mutual Fire Insurance Companies found some years ago that there was an increasing demand for some sort of a guard for fire services and as there was nothing at the time on the market which would do the work experiments were made. A meter was finally developed which measured the small flows and leakages accurately by a small meter in a by-pass around a weighted check valve in the main passage. Then for larger amounts of water, as in case of fire, the check valve opened and gave a free passage. When this occurred the water through the main passage was measured proportionately on a small dial. Several of these meters are in use and giving satisfaction. Improvements soon after in commercial devices made further developments of this idea unnecessary.

VENTURI METERS.

81. Venturi meters have been proposed for fire services. The friction loss which they cause may be very small, but they are not well adapted for measuring the low flows which it is usually desired to control. Again, it is important, wherever the Venturi meter is used, that the throat be not so small that it may readily become choked by any foreign matter possibly coming along in the pipe, and this is quite as vital as that the friction loss should be low with the usual fire drafts. There is always a chance when pipes are being laid, or when repairs are being made, that some foreign thing, such as a block, a large stone, a pair of overalls, or something of the kind, may be left in the pipe, or may be pushed in by boys who not uncommonly get into the trenches when the men are gone. It is consequently very necessary that the throat of a fire service meter be sufficiently large to pass anything of this kind likely to come along. This caution is given while fully recognizing the merits of this type of meter, because a number of cases have arisen where, in a desire to measure quite small flows, throats only a few inches in diameter have been proposed in 6, 8, or 10-in. pipes.

FIRE SERVICE METERS.

82. The Hersey Manufacturing Company, Boston, and the Neptune Meter Company, New York, have developed devices with special reference to fire service requirements. These were designed with the idea that the friction loss for large flows must be small and that the main passageway must be practically unobstructed when open so that there would be no more chance of a full flow of water being prevented than in the various other fittings used in ordinary water works practice. Provision was then made for measuring or indicating the flows. These special devices will satisfy all of the requirements for those cases where the simpler methods previously described cannot be accepted, and where the cost of this additional equipment is necessary.

83. Hersey Detector-Meter, Model D. M.—This device consists of a check valve in the main passage, slightly weighted and having a grooved seat with the grooved space connected with the atmosphere, thus giving a differential action. Around the check valve is a by-pass of smaller size, containing an ordinary disc meter. In operation the smaller flows are forced through the by-pass by the main check valve and are measured accurately by the small meter. If more water is drawn the main check valve opens and gives a free water way. At the same time the outlet from the differential seat discharges water into the atmosphere and a small meter is connected to this outlet and, by recording the amount of water discharged, gives an approximate measure of the time the main clapper has been off its seat. The device is therefore a meter for the smaller flows and a detector for the larger ones and under many conditions has given all the protection needed for a fire service.

84. Hersey Detector-Meter, Model F. M.—This device is a development of the first detector-meter, but adds to it a second meter, arranged to measure the larger flows proportionately, thus producing a device which would measure all flows and meet the demand for a meter which records all of the water used under any conditions and leaves nothing for further adjustment.

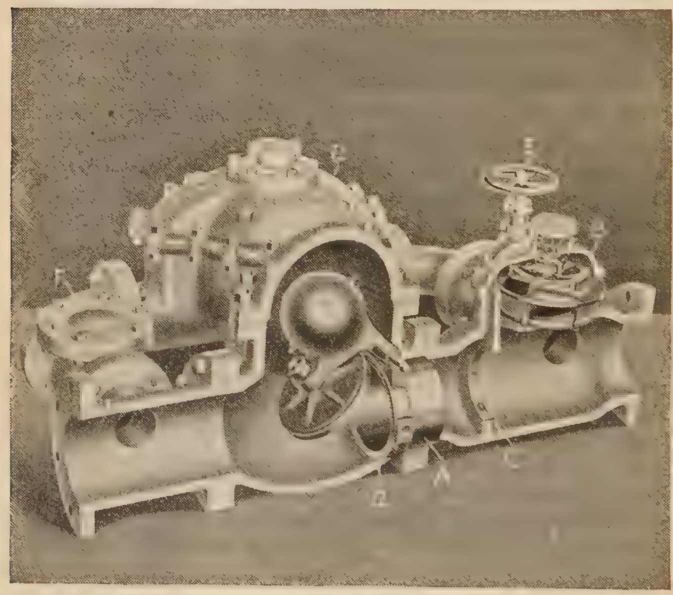


Fig. 41. Detector-Meter. Model "F. M."
(Courtesy of Hersey Manufacturing Co.)

85. The main check valve and the by-pass arrangement are the same as in the detector except that the passage from the differential seat is controlled by a small valve which closes it when the check valve opens and opens it again when the check valve returns to its seat. This is to prevent waste of water through this outlet while the check is open, while still retaining the differential feature. The whole device is shown in Fig. 41. The additional feature is just up stream from the main check valve and consists of a friction ring (*C* in the cut) which is somewhat smaller than the main channel which has been enlarged at this point, but only slightly smaller than the diameter through the check valve itself, which is the same as the nominal size of the meter. On top of this enlarged passage is a small meter (*B* in the cut), also in a by-pass cast in this special fitting. When water begins to flow through the main line it is slightly restricted by the friction ring and a part of it diverted through the small by-pass. This diverted portion is always a fixed percentage of the total flow through the friction ring and the meter *B* is arranged so that it records the total flow acting on the proportional principle. The sum of the readings of the two meters *B* and *D* gives the total flow which has passed through the pipe in any given time.

86. Neptune Trident-Protectus Meter—This meter has all the working parts in one casing. There is a full sized check valve in the main passage which is held closed by a weight attached to a cam so that the weight effect decreases as the clapper opens. An ordinary disc meter is installed in a by-pass on one side and a current meter on the other side of the main waterway. The arrangement of the parts is shown in Fig. 42. In operation small flows are forced through the disc meter as the main check valve is held closed by the weight. With larger flows the main check valve opens and gives a free waterway. The flow through the disc meter is stopped by means of the butterfly valve at the outlet end of the by-pass which is closed by the opening of the clapper. The flow is then measured proportionately by the current meter which is operated by the flow through its by-pass. The sum of the readings of the two meters gives the total flow which has passed through the pipe in any given time.

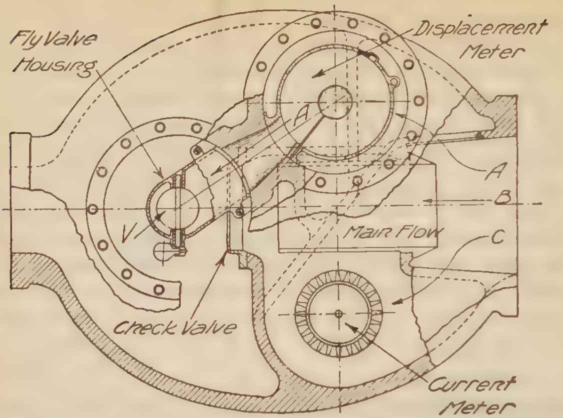


FIG. 42. NEPTUNE TRIDENT-PROTECTUS METER

(Courtesy of Neptune Meter Co.)

87. Installation of Meters—Whenever special meters of this type are used, they are ordinarily located at the point of entrance to the plant and advantageously can be placed in a brick or concrete pit to permit of ready accessibility. The repair valve on the plant side of the meter should be located in the same pit. See page 394. Street valves generally are located at the water supply main. It is advisable to provide a full sized by-pass around any meter to guard against water being shut off in case of repairs to the meter, the valves being so arranged that the meter can be cut out and the fire equipment meanwhile kept intact with full water pressure constantly on the system. The valve in the by-pass should preferably be of the indicator post type.

88. Both the Hersey and Protectus meters are provided with check valves so that these meters act as check valves in a system. Occasionally another check valve is used on the plant side to give additional protection.

89. As the friction losses in these meters are not excessive, it is often feasible to use a 6-in. device on an 8-in. pipe and sometimes on a 10-in. pipe, thus saving cost and still being able to pass all the water available with a low total friction loss. This suggestion is merely adopting the general idea of the Venturi throat and making use of the fact that a moderate restriction at one point, made by somewhat tapered reducers on each side, so that there is no serious eddying of the water, does not cause much increase in friction loss. The main point, as in the Venturi meter, is never to have the smallest passage so restricted that there will be danger of it becoming obstructed by some foreign matter coming along in the water.

GENERAL REMARKS.

90. Many years of experience in fire protection matters make it proper to suggest that it is in every way desirable that there should be cooperation between the water works officials and the owners and managers of protected properties. Water works authorities are charged with the responsibility of maintaining their systems in efficient condition, so that they may always supply the water needed for domestic and manufacturing purposes, and be ready at any instant to furnish a large quantity of water to extinguish fires. Further, they must prevent all needless wastes and all improper uses of water and must, in fairness to the community or to the water company, receive a proper return for all water used for purposes other than fires.

91. On the other hand, the progressive property owner provides, at considerable expense, protective apparatus which greatly reduces the chance of a sweeping fire in his property, that in many cases might readily extend to adjacent buildings. Further, he makes almost impossible a serious interruption of business, which would also throw out of work employes, and even in some cases result in the removal of an industry to another town, thus crippling the resources of the community. Again, the protected property is much less likely to call for a large amount of service from the public fire department.

92. If, therefore, it can be recognized that the interests of the water works officials, the protected risk, and the community are largely identical, it will be granted that to work together in a spirit of friendly cooperation will be for mutual interest. Where this spirit prevails, there is an absence of that friction and that tendency to make troublesome restrictions which are likely to arise where both sides do not work together in a frank, businesslike manner.

GAGES

93. Gages play an important part in fire protection. There are three types used:

a—Indicating gages of the spring type.

b—Recording gages, used on steam supplies, city water systems, etc.

c—Mercury gages used to indicate height of water in tanks.

94. The National Board Rules covering sprinkler systems call for 4½″ dial, spring pressure gages, with maximum limit equal to twice the working pressure where installed. Calibration is generally 100 lbs., 250 lbs., or 500 lbs. Such gages will answer for almost every fire protection need where indicating types of gages are required. Certain manufacturers make gages meeting both the National Board and the Factory Mutual specifications. A number of manufacturers make standard recording gages, and a more limited number reliable mercury ones.

95. Gages are used in situations such as:

a—On city water connections to hydrants, sprinklers, standpipes, and pump suctions. In the latter case a compound pressure and vacuum gage may be necessary if the pressure is low. Where great reliability is placed on a city connection, a recording gage is often used.

b—On steam supplies to pumps. Recording gages are warranted where pumps are automatic.

c—On discharge side of pumps of every type.

d—At one or more points on distribution system to show existing pressures from any one of several sources.

e—On sprinkler systems:

1—Above and below each alarm check or dry pipe valve.

2—At air pump supplying pressure tank.

3—On pressure tank.
4—In air supply feed to each dry pipe system.
6—At base of gravity tank risers.
7—At tops of risers, used also in connection with flow tests at that point.
8—At draw-offs on risers where flow tests are made.

STEAM FIRE PUMPS

96. The steam fire pump, properly designed and installed and provided with adequate steam and water supplies, forms a most reliable and satisfactory supply for sprinklers and for yard hydrants. It ranks second in general value to the water works connection, especially if provided with practically an unlimited suction supply. Cases are on record where serious, stubborn fires in large structures or in materials such as cotton have required continuous pump service literally for days. See Fig. 44, page 340.

97. For many years the leading pump makers have been building so-called Underwriters' Steam Pumps, in general accord with the National Board specifications, the essential installation features of which appear in this section. Fig. 44 illustrates such a pump. The need of this type of pump was brought out by the failure of so-called "trade" pumps when it was attempted to run them at full speed and capacity for considerable periods of time. A pump which worked well under slow speed, and perhaps low efficiency, either broke down entirely when subjected to the unusual strain of high speed and high pressure, or failed to deliver anything like its proper capacity because of wear and leakage.

RESERVED FOR FIRE DUTY.

98. It is virtually impossible to use a steam fire pump for domestic service and to have it in perfect condition at time of test or fire. The use of bronze in the construction of Underwriters' Pumps insures certain starting after disuse, and it also causes pumps to wear badly under constant running. The only safe rule is to reserve fire pumps for fire duty, to turn them over preferably daily, and periodically to test them under pressure up to capacity.

SIZE.

99. The steam pump should generally be of sufficient size to feed a reasonable number of sprinklers and at the same time furnish two or more efficient hose streams. A pump which would deliver 500 gals. per minute used to be considered sufficient for the ordinary plant, but it is evident that such a pump cannot feed sprinklers and hose streams at the same time, and the false economy of small pumps has been so often demonstrated that we find a general tendency now towards larger pumps, which is certainly better practice. It is always well to consider that sprinklers may later on be installed.

100. Where pumps may supply hose streams, as is nearly always the case, a 750-gal. pump should certainly be the minimum even for small plants, and for the ordinary plant a 1,000-gal. pump should be the minimum. The cost of the additional pumping capacity is very small compared with the cost of fire protection as a whole, and the ability properly to supply, say, fifteen to twenty sprinklers and at the same time give two good hose streams, may mean the difference between an insignificant fire and serious loss.

LOCATION.

101. The location of pump and boilers is one of the utmost importance, the latter being as vital as the former, as it is evident that steam must be maintained and fire and smoke must be kept out of both boiler and pump rooms. This means preferably a detached boiler and pump house. It not detached, the boiler room should have a standard cut-off from the remainder of the plant and the pump room can either be detached or adjoin the boiler room. For the sake of cleanliness and general attendance, it is better to have the pump in a separate room from the boilers. Pump room should preferably be fire-resistive and it should be possible to enter it from the outside of the building. Further, the pump room should be light and airy.

BOILER CAPACITY AND FUEL.

102. The rule is that not less than 40 boiler h.p. shall be available for each 250 gals. rated capacity of fire pump. Boiler fires are frequently banked at night and excess boiler capacity is very advisable. Furthermore, boilers must be examined and tested at more or less frequent intervals, and several boilers, therefore, give better protection, for at least one should be in service at all times. Plants have been destroyed by fire breaking out while fire pump was without steam because of boilers being all down at once.

103. Water must be available for boilers at time of fire, and feed water supply for boilers should be so arranged that it will not be crippled by broken pipes or taken away by fire engines or hose service. It is good practice to have an emergency boiler feed supply taken directly from fire pump discharge and on the pump side of the main gate valve. This insures boiler feed water as long as fire pump has suction. Ample fuel for boilers is obviously essential. See Fig. 43.

STEAM SUPPLY.

104. Many fire pumps have been put out of service at time of fire by the breaking of a steam line leading to the pump or to some other apparatus. Reliability of the steam supply is important and frequently overlooked. The following is essential:

a—Preferably special line from boiler room header to fire pump. See Fig. 43. Line to be as short as possible.
b—If fire pump line supplies branches, these to be con-

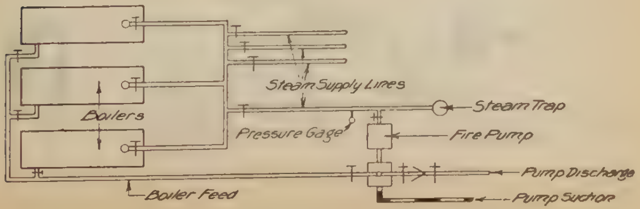


FIG. 43. STEAM SUPPLY FOR FIRE PUMP

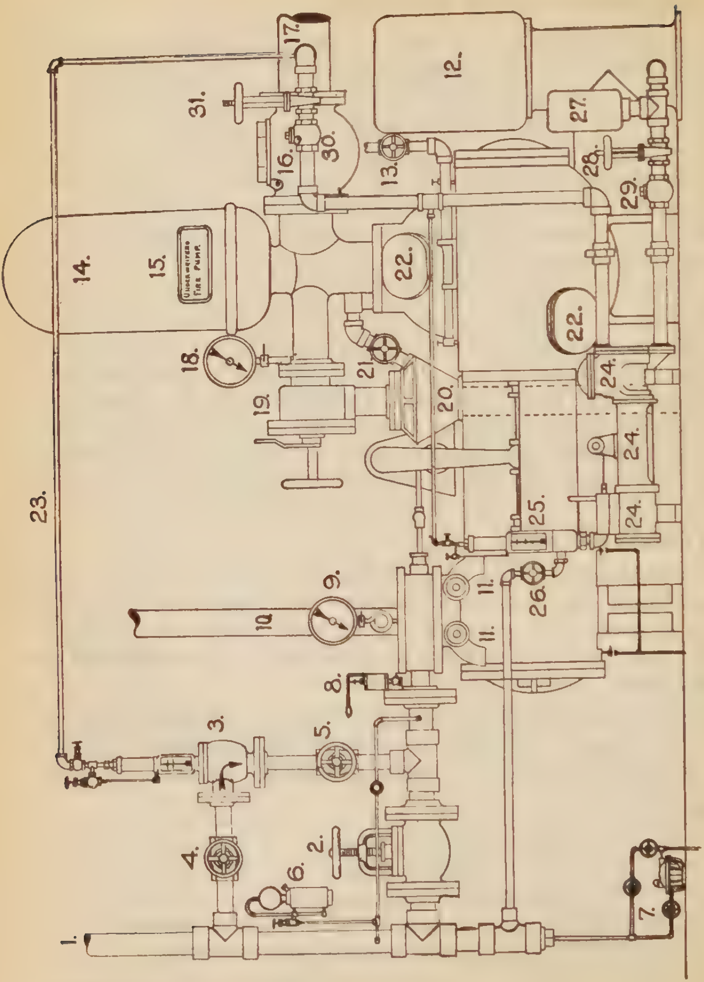


Fig. 44. National Standard Steam Fire Pump and Auxiliary Pump and Connections.

trolled through valves preferably located in fire pump room.

c—Every branch leading from boiler room header to have individual and readily accessible valve.

d—Where steam line is exposed by buildings, lumber piles, etc., line should be run underground, or there should be loop supplies so located and so valved that the possibility of both branches being interrupted at the same time is exceedingly remote.

e—Steam line requires proper pitch and trap to remove condensation.

105. A pressure gage on steam line in pump room is advisable.

THE NATIONAL STANDARD STEAM PUMP

KEY TO FIG. 44

STEAM END—MAIN PUMP.

1. Steam supply pipe direct from boilers, independent of all other pipes.
2. Main throttle valve.
3. Automatic governor on by-pass around main throttle. For ordinary conditions governor does not need to be full size of steam inlet; 1½ or 2″ is sufficient for 1000 gallon pump.

4–5. Globe valves to permit governor to be removed for repairs without crippling pump.

6. Sight feed lubricator.
7. Steam trap.
8. Hand oil pump. Glass body with 1 pt. capacity.
9. Steam gage attached directly to steam chest.
10. Steam exhaust pipe direct to atmosphere.
11. Hand wheels operating cushion valves for regulating stroke of pump.

WATER END—MAIN PUMP.

12. Suction air chamber.
13. Priming connection from priming tank or other reliable water supply.
14. Air chamber.
15. Name Plate.
16. Horizontal straightway check valve.
17. 6 or 8″ pipe extending from pump discharge thru wall of pump house. Hose valves each should have independent gates, and wall opening must be protected against freezing.
18. Duplex spring water-pressure gage.
19. Relief valve, spring pattern.
20. Open cone on waste pipe, which should be carried to outside. If pump drafts from cistern or other limited supply of water, waste pipe should discharge into this supply.
21. Test valve to permit discharging water into discharge cone without operating relief valve.
22. Large hand hole plates to give access to pump valves.
23. Brass tube, ½″ in diameter, water pressure connection to governor.

AUXILIARY PUMP.

24. Body of auxiliary pump, drafting from fire pump suction and discharging into its discharge. See Fig. 46, Plan A.
25. Governor set 10 lbs. higher that fire pump governor.
26. Throttle. By-pass not required for governor as on main pump.
27. Suction chamber.
28. Suction gate valve.
29. Suction check valve.
30. Discharge check valve.
31. Discharge gate valve.

SUCTIONS.

106. Sources of suction found in industrial plants include:

a—Connection from water works main.

b—Connection from river, brook, pond, flume, or penstock.

c—Connection from special reservoirs reserved for fire or to general reservoirs used for both fire and domestic purposes.

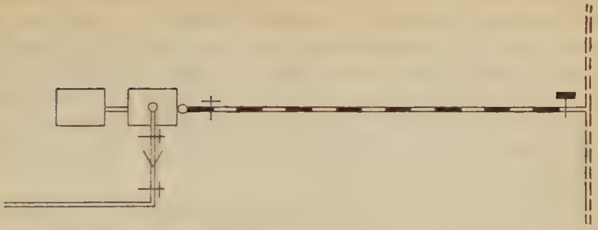
d—Connection from special tanks.

107. Combinations of these, as for example, "a" and "d" are occasionally found. See rule 56 and page 350.

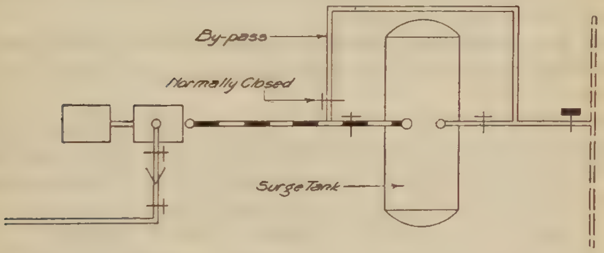
108. If water works pressure is insufficient to act as primary supply to sprinklers or hydrants, a pump suction can be arranged as shown in A and B, Fig. 45. Some water works managements refuse to allow any direct connection and some insist on a surge tank. The valves next to the pump on the discharge side are required only where the other valve is outside the pump room.

109. If water works connection constitutes an automatic supply, and if pump is to be used as a booster, the arrangement in C is correct. The main pipe check is between gates to permit repairing it without shutting down pump.

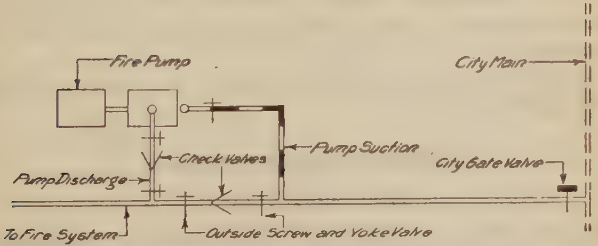
110. Suctions to rivers, brooks, or ponds almost always require protection against driftwood, weeds, and refuse and it is necessary so to locate suctions that minimum of mud will be likely to be drawn into system. A concrete intake with two vertical plate screens, one of which can be removed for cleaning while the other affords protection, is ideal. See Fig. 48, page 363. Where there is no pressure head on the suction supply, a brass or copper wire screen of about ½-in. mesh and No. 10 B. & S. wire, secured to a metal frame, makes a serviceable form of screen. The screen should have an effective area equivalent to one square inch for every gallon per minute of pump capacity. Where



A - DIRECT SUCTION



B - SUCTION NORMALLY FROM SURGE TANK



C - CITY ON FIRE SYSTEM - PUMP BOOSTS PRESSURE

FIG. 45. SUCTION ARRANGEMENTS FOR PUMPS DRAFTING FROM WATERWORKS CONNECTION

pumps take suction under a head, as from a penstock, a suitable form of enclosed strainer is essential. Where lifts are 15 ft. or more or where long suction pipes are necessary, foot valves are commonly used. Certain manufacturers furnish approved types of valves having large clear waterways and non-corrodible bearings. The types of foot valves with relatively small openings and of a design that can be readily clogged are particularly objectionable.

111. Where suctions would be long, particularly where several pumps are to draft from river, brook, or pond, it is good policy to have a gravity line filling a suction well located close to pump house. Screen protection for such intake, of course, belongs at the point of supply.

112. It is important to ascertain minimum water supply conditions, because these may make an apparently good suction undesirable.

113. Where suctions are taken from rivers having heavy fluctuations in level, it has been found necessary to place pumps in deep wells below minimum level of river, or even to have pumps on skids raised and lowered on sloping river bank in order to keep pumps within reasonable suction distance of river. Adjustable suction, discharge, and steam or electric connections then of course become necessary.

114. If a reservoir is used jointly for fire and domestic purposes, it is good policy to have domestic suctions extend only part way to bottom so that a definite amount will be reserved for fire purposes.

115. Above-ground reservoirs and tanks will require heating in cold weather.

NATIONAL BOARD RULES

(Edition of 1915)

116. The following sections of the regulations of the National Board of Fire Underwriters for the manufacture and installation of Steam Fire Pumps are reproduced as being of general interest.

UNIFORM REQUIREMENTS.

The following specifications for the manufacture of Steam Fire Pumps, developed from those originally drawn by Mr. John R. Freeman, are now used throughout the whole country, having been agreed upon in joint conference by representatives of the different organizations interested in this class of work.

THE NATIONAL STANDARD PUMP.

1st.—Its steam ports and water passages and air chamber are made much larger than in common trade pumps, so that a large volume of water can be delivered in an emergency without water hammer.

2d.—It is "rust proofed" that it may start instantly after disuse, by making its piston rods and valve rods of Tobin bronze, instead of steel; its water pistons, stuffing boxes and rock-shaft bearings of brass, instead of cast-iron. Its valve levers are made of steel or wrought-iron forgings, or of steel castings.

3d.—The following necessary attachments are all included in the price of the "National Standard Pump," viz.:—a vacuum chamber, two pressure gauges, a relief valve, a set of brass priming pipes, 2 to 6 hose valves, a stroke gauge, a capacity plate, an oil pump, a sight feed lubricator and a cast-iron relief-valve discharge-cone.

By reason of the larger ports, passageways and pipes, its larger number of valves, and the added attachments, and generally superior construction a "National Standard" pump costs more than a common trade fire-pump, but the cost per gallon which these pumps can *deliver in an emergency* by reason of their large passageways, etc., is no greater than for the old style of fire-pump and is well worth this extra cost.

Finally it should be remembered that these specifications cover only the outlines of the design, and that all pumps built under them are not of equal merit, for certain of the pump factories possess a broader experience and better shop facilities than others, and that the responsibility for first-class workmanship and strength of materials rests on the pump manufacturers, and not on the insurance companies.

NATIONAL STANDARD SPECIFICATIONS.

3. Sizes of Pumps.

Only the four different sizes given in the following table will be recognized for "National Standard" pumps:

The multiplicity of odd sizes of "Trade Pumps" is confusing, and different makers have, in the past, estimated the capacity in gallons according to different arbitrary standards.

NATIONAL STANDARD PUMP SIZES

Pump Sizes.			Ratio of Piston Areas.	Capacity at 100 lbs., at Pump.			Boiler Power Required.		Full Speed.	
Steam.	Water.	Stroke.	About	Number of 1⅛-in. Streams.	Nominal Gals. per Minute.	Actual Gals. per Min. as per Art. 4.	Horse Power.	Steam Pres. at Pump, lbs.	Rev. per Minute.	Piston Travel Feet per Minute.
14 12	x 7 x 7¼	x 12 x 12	4 to 1	Two	500	483 520	100	40	70	140
16	x 9	x 12	3 to 1	Three	750	806	115	45	70	140
18 18½	x 10 x 10¼	x 12 x 12	3 to 1	Four	1000	999 1050	150	45	70	140
20	x 12	x 16	2¾ to 1	Six	1500	1655	200	50	60	160

4. Capacity.

It is all right to run fire pumps at the highest speed that is possible without causing violent jar, or hammering within the cylinders. Considerations of wear do not affect the brief periods of fire service or test, hence these speeds are greater than allowable for constant daily duty.

Careful experiments on a large number of pumps of various makes at full speed, show that in a new pump with clean valves, and an air-tight suction pipe, and less than 15-ft. lift, the actual delivery is only from 1½ to 5 per cent. less than plunger displacement. This slip will increase with wear, and for a good average pump in practical use, probably 10 per cent. is a fair allowance to cover slip, valve leakage, slight short-stroke, etc.

Men sometimes ask why, if they can run a pump smoothly so as to get a delivery of 1,000 gals. per minute, we should not accept it as "a thousand-gallon pump," irrespective of its suction valve area or its exhaust port area or the size of its cylinders.

To this we reply that when new and favorably set almost any pump built according to these specifications can run at a much greater delivery than here rated, but when lift is unusually high or suction pipe long, no pump can be run so fast as on, for instance, a 5-ft. lift. A solid foundation is also a great aid in running a pump fast.

Standard 500-gal. pumps have often delivered 800 gals., and 1,500-gal. pumps have delivered 2,000 gals., but some margin must be allowed for unfavorable conditions and for deterioration as pump grows old, or for absence of an expert to get its utmost duty

39. Pipe Sizes.

Water and steam pipe connections must have standard flanges to connect with pipes of the sizes given below:

Size of Pump, Gal. per Min.	Diameter of Suction Pipe, Inches.	Diameter Discharge Pipe, Inches.	Steam Pipe.	Exhaust Pipe.
500	8	6	3	4
750	10	7 or 8*	3½	4
1,000	12	8	4	5
1,500	14	10	5	6

* Eight-inch preferred, this being the more common size for valves, fittings, and pipes.

These suction pipe sizes, although larger than common for trade pumps of the same size, are believed to be amply justified by experience, and exert a powerful influence toward enabling the pump to run smoothly at high speed with water cylinders filling perfectly at each stroke. No defect is more common than restricted suction pipes.

46. Priming.

For 1,000- and 1,500-gal. pumps, the priming pipes must be 1¼ in. For the 500- and 750-gal. pumps, the pipes must be 1 in. Pump-makers are to furnish these pipes and the fittings called for below, and are to connect them up providing a 2-in. outlet, looking upwards, ready for the supply from the priming tank.

A priming tank is provided by the purchaser in all cases where there is ever to be any lift on the suction. It is generally advised that this tank have a capacity of one-half of what the pump can throw at full speed in a minute. This means 250 gals. for a 500-gal. pump and 500 gals. for a 1,000-gal. pump, etc. It is the intention to make the pump a truly "independent source" of supply, therefore the need of a special priming tank.

Author's Note—Satisfactory priming connections may be secured from city water, from domestic system, and from other pumps. Duplicate priming connections for important pumps may be worth while.

TESTS FOR ACCEPTANCE

48. Test for Smoothness of Action.

Provide outlets for the water; start the pump slowly, gradually open steam-throttle to bring the pump to full speed. The pump should run smoothly at the rated full speed of 70 revolutions per minute (or 60 revolutions if a 1,500-gal. pump) with full length of stroke, and meanwhile maintain a water pressure of 100 lbs. per square inch.

If the hose lines are short, or discharge is too free, partly close the water outlet valves, thus throwing an extra back pressure on the pump equivalent to that which would be produced through a greater length of hose.

During this trial it is preferable to discharge the water through lines of 2½-in. cotton rubber-lined hose preferably each 150 ft. long, each connected directly to the hose outlets on the pump, and each line having a 1⅛-in. smooth nozzle at its outer end. Two lines should be connected for a 500-gal. pump, three for a 750, and so on, having as many lines as rating of pump requires.

A hose line 150 ft. long, with an inside surface of average smoothness, and with a 1⅛-in. nozzle attached, will require about 80 lbs. pressure at the pump to discharge 250 gals. per minute, and the nozzle pressure will be about 45 lbs. Therefore, with lines attached as above, a pressure at the pump of about 80 lbs. should represent a discharge about equal to the rated capacity of the pump, and would ordinarily correspond with the rated full speed revolutions.

If the pump runs smoothly under these conditions, it is well to open the throttle somewhat further, and bring the pressure at the pump up to 100 lbs. This will give a discharge of about 280 gals. per stream, or about 12 per cent. in excess of the rated capacity. The revolutions will, of course, correspondingly increase, and under all ordinary conditions a pump should run smoothly at this higher capacity, though a little more vibration and pounding would be expected than when running simply at its rated speed.

These tests should be made with cushion valves wide open, and there should be no noteworthy water hammer or valve-slam, neither should there be any striking of piston against steam cylinder heads when running at full speed against little or no load. Sometimes valve-slam is not the fault of the pump, but arises from an obstructed suction pipe. It is objectionable to doctor water hammer in a pump by snifting air into the suction, as this cuts down the efficiency and is a poor expedient.

The quietness of that part of the hose near the pump, or its freedom from rubbing back and forth crosswise an inch or more with each pulsation of the pump, is a good index of the pump maker's skill in securing uniform delivery. Bad pulsation quickly wears holes in the hose, and to reveal this is the object of testing with hose connected directly to the pump.

49. Test of Internal Friction.

This is shown by the reading of steam chest gauge compared with water pressure gauge at air chamber.

Tests have generally run about as follows, for pumps running at full rated speed:

Size of Pump Gals. per Min.	Ratio of Steam Piston Area to Water Piston Area.	Water Pressure Lbs. per Sq. In.	Steam Pressure Theoretically Necessary, Disregarding Friction.	Excess of Steam Pressure Needed to Overcome Friction, Back Pressure, Etc.	Actual Steam Pressure Found Necessary at the Pump.
500	4 times	100	25	15	40
750	3 "	100	33	12	45
1,000	3 "	100	33	12	45
1,500	2¾ "	100	36.5	13.5	50

The steam pressure needed will vary slightly with the freedom of the exhaust pipe and with the tightness of the packings, etc., but a steam pressure of 45 lbs. at the steam chest should suffice for 100 lbs. water pressure on the pump in proper adjustment.

50. Test of Strength and Tightness.

First, shut the main valve between the pump and the fire system to avoid possible injury to joints or fittings, then shut all water outlets nearly, but not quite tight, so pump will move very slowly. Screw safety valve down hard. Slowly and carefully admit steam pressure sufficient to give 240 lbs. per square inch water pressure.

With this extreme pressure all joints should remain substantially tight, and the slow motion of the pump should be tolerably smooth and uniform. (The leakage of a few drops here and there and a little unsteadiness of motion are to be expected.)

If boiler pressure is above 85 lbs., the safety valve on pump should be attached and screwed down only enough to hold the required pressure. For with 100 lbs. or more of steam the water pressure might be carried too high.

After completing the above test slack off on safety valve, setting it so that it will begin to open at about 100 lbs. pressure.

51. Test of Capacity of Safety Valve.

The relief valve may next be tested by first adjusting it to pop at 100 lbs., then shut the main outlet to pump, and then shut the hose gates one by one, and thus force all the discharge through the relief valve, meanwhile opening steam throttle, so as to run pump first at two-thirds speed or about fifty revolutions per minute, and finally at full speed (seventy revolutions). The safety valve (relief valve) should carry all this and not let the pressure rise above 125 lbs.

The pressure in a quick-moving fire-pump necessarily fluctuates 5 to 15 lbs. at different points in stroke, and an air chamber of reasonable size cannot wholly remove this. Therefore the safety valve must be set at about 15 lbs. higher than the intended average working pressure; otherwise it will get to jumping with almost every stroke.

52. Test of Internal Leakage or Slip.

Set safety valves at 115 lbs., shut all water outlets, admit steam enough to give 100 lbs. water pressure, then pump will move very slowly under the influence of the leakage past plungers; about one revolution of pump per minute shows a proper accuracy of fit. Anywhere from one-third to two revolutions per minute is satisfactory.

Too tight a fit is bad, as if not exceedingly uniform it induces scoring or fretting of the metals. Moreover, should pump happen to be run dry for a few minutes before catching its suction a slight warming and expansion of the plunger may cause it to stick and fret.

53. Test With Maximum Working Pressure.

For this, alternately shut down the main outlet gate and adjust the handwheel of the safety valve, and open up on the throttle as may be required, running pump at say one-half speed (or, in experienced hands, at full rated speed), and note the greatest water pressure which the full boiler pressure (unless boiler pressure is above 85 lbs.) will yield with pump at full speed.

Sometimes it may be necessary to force water through very long lines of hose, or to an unusual height.

Steam fire engines are not infrequently called on to give 200 lbs. per square inch water pressure.

To test short hose lines with anywhere near so high a pump-pressure is dangerous, lest the nozzle kick and pull itself away from the man holding it and thresh around; but the ability of the pump may be tested by putting this high-pressure delivery mainly through the safety valve, or in part through the partially closed main outlet gate.

It is not advisable to carry this water pressure above 200 lbs. in the field test, although in the shop test the water pressure is carried to 240 lbs., and engine driver should stand with his hand on the throttle.

54. Test for Maximum Delivery.

This can best be tried by adding one or, in some cases, two more streams than the pump is rated to deliver by attaching the extra lines of hose to some hydrant near, and then speed up the pump gradually, to see how fast it may be run before violent pounding or slamming of valves begins.

Sometimes the increased delivery can be drawn off through an open hydrant-butt meanwile holding sufficient back pressure to show 100 lbs. on the water gauge by partly closing the discharge valve.

The engine driver should stand with his hand on or near the throttle when thus speeding the pump.

It is all right to run a fire-pump up to the utmost speed possible before water hammer begins, and very often a pump, while new and if favorably set up, can deliver 25 to 50 per cent. more than rated capacity; nevertheless, although expert treatment can force 1,000 gals. from a 16 × 9 × 12 pump we can rate it as only a 750-gal. pump. *There must be some margin to allow for wear and for the possible absence of the expert at time of fire.*

The main points of difference between the "National Standard" and the "Trade Pump" are:

Brass plungers instead of cast-iron plungers.
Wrought-iron side levers instead of cast-iron.
Bronze piston rods and valve rods instead of iron or steel.
Pump has brass-lined stuffing boxes instead of cast-iron.
Rock shafts are brass bushed.
Area of water valves is 25 to 50 per cent. greater.
Steam and exhaust passages 20 to 50 per cent. greater.
Suction pipe connections two to four inches greater diameter.
Cushion valves better arranged.
Air chamber is made much larger.
Shells and bolting are warranted especially strong.

The following necessary fittings are included in the price, and regularly furnished as a part of this pump, viz.:

A capacity plate.
A stroke gauge.
A vacuum chamber.
Two best quality pressure gauges.
A water relief valve of large capacity.
A cast-iron relief valve discharge cone.
A set of brass priming pipes and special priming valves.
From two to six hose valves.
A sight-feed cylinder lubricator connected above throttle.
A one-pint hand oil pump connected below throttle.

56. Suction Pipe.

a—Where pump takes its water under a lift, the size of suction pipe should be in accordance with the following table:

Lift not exceeding	Length not exceeding	Size of Pump (gallons per minute)			
		500	750	1,000	1,500
10 ft.	50 ft.	8 in.	8 in.	10 in.	12 in.
10 ft.	100 ft.	8 in.	10 in.	10 in.	12 in.
15 ft.	200 ft.	8 in.	10 in.	12 in.	14 in.

Suction pipes longer than 100 feet are much better arranged by providing an intake well as near as practicable to pump and supplying the well through a large tile pipe on a down grade from source of water supply. This inlet pipe to well should be provided with a gate valve.

Lifts greater than 15 feet should be avoided, or an intake well provided permitting a short suction pipe, and if necessary the pump depressed to reduce the suction lift to less than 15 feet.

Where pump takes its water under a constant head, the size of suction pipe should not be smaller than given in the following table:

Head (ft.) at least	Length not exceeding	Size of Pump (gallons per minute)			
		500	750	1,000	1,500
10 ft.	250 ft.	6 in.	8 in.	8 in.	10 in.
10 ft.	500 ft.	8 in.	10 in.	10 in.	12 in.
5 ft.	700 ft.	8 in.	10 in.	12 in.	14 in.

Long suction pipes should be avoided wherever possible, and when over 500 feet long the inspection department having jurisdiction should be consulted.

Each elbow used in the suction line should be considered equivalent to 10 feet of pipe. A special reducing casting should be provided to connect pump suction opening with its suction pipe when of different diameter.

The satisfactory operation of any pump depends very largely on the proper installation of its suction pipe. The great variety of conditions that exist in field situations make it difficult to state specifically the proper size and arrangement of pipe needed without making a special engineering investigation, but to guide one within safe limits and to avoid uncalled for expense in cast iron pipe, the above rules are submitted as giving roughly the limits within which it is advised to work. Where doubt exists, the inspection department having jurisdiction should be consulted.

b—A short suction pipe, if well supported, should preferably be of flanged pipe with rubber gaskets. If of some length and in yielding soil, bell and spigot pipe should be used, and the joints filled with lead and tightly calked. Yarn and similar materials should not be used as a substitute for lead in suction pipe joints.

c—Great care should be taken in laying the suction pipe, so that it shall have a constantly ascending grade from the water supply to the pump.

If high places or summits are permitted, they are likely to give constant trouble by the accumulation of air, thereby cutting down the area of the pipe and reducing the amount of water possible to be delivered at the pump.

d—The average situation does not require a **foot valve**, and this fitting should be avoided except in cases of very long suction pipes or very high suction lifts. Any foot valve that may be installed should have bronze seats and its valve faced with some suitable yielding material, such as leather, and should be of a design and construction that will not unduly restrict the flow of water toward the pump. The foot valve should be so located as to be readily accessible and be provided with hand holes.

With a good efficient priming arrangement as described in Art. 46 no serious delay should be experienced for most situations.

Where foot valves are employed they often give a false sense of scurity, and it is frequently found that with a fire pump left standing several days the water will have leaked back, so that it is no better than if no foot valve had been used.

A foot valve must of necessity generally be located where it is accessible for quick repairs, and as they grow old, foot valves are often a source of trouble. Where a suction pipe is exposed even slightly to frost, a foot valve is specially objectionable.

When installed to aid a difficult situation they should be of a design having a clear water way fully equal to the suction pipe.

e—Wherever a strainer is advisable, it should be so constructed and arranged that it can be cleaned or repaired without disturbing the suction pipe itself. A brass or copper wire screen of about one-half inch mesh and No. 10 B. & S. wire, secured to a frame sliding vertically at the entrance to the intake, makes a serviceable arrangement, and permits of ready cleaning and overhauling. The screen should have an effective area equivalent to at least five times the area of the suction pipe and preferably ten times. Double screens are advised, so arranged that either can be removed for cleaning while the other remains in service. The ordinary combination foot valve and strainer should be avoided. See page 363.

f—Except as provided for in the installation of steam pump governors and auxiliary pumps, the connecting of any other pipe to the fire pump suction should always be avoided, particularly the suction pipe of any auxiliary pump, such as a condenser or mill pump.

It is sometimes claimed that the daily use of a second small pump drawing its water from the fire-pump suction is an advantage in that it insures the working order of the suction supply as a whole. This is only true to the extent of the smaller pump's capacity, and is deceptive as to the pipes' condition when called on to the full capacity of the fire-pump. It has frequently happened that a partially obstructed suction pipe or strainer, although supplying a smaller pump very well, will fail completely to supply the fire-pump at its rated speed. The liability of air leaking into the fire-pump suction from the auxiliary pump connection is also an objection to the connecting up of two suction pipes. For similar reasons, the use of one suction pipe by two fire-pumps should, if possible, be avoided. As a rule, where two fire-pumps have taken water through the same suction pipe as good results have not been obtained as where the suction pipes were entirely separate.

58. Steam Pipe. c—In general, a reducing valve should not be placed in the steam pipe supplying the fire pump.

At plants employing high pressure steam there is a growing tendency to introduce a reducing valve between the boilers and the fire pump, on the ground that such a valve would better protect the fire pump and the connecting fire system. However, any valve of this sort introduces a possible obstruction in the steam line in case it becomes disarranged, and in most cases the desired protection can be obtained by connecting a steam pop safety valve to the steam chests of the pump and set to pop at about 100 lbs. This valve should be piped outside of the pump room, and if possible to some point where the discharge could be seen by the pump attendant.

59. Exhaust Pipe. The exhaust pipe should run direct to the atmosphere, and should not contain valves of any sort. It should not be connected with any condenser, heater or other system of exhaust piping. If long, and containing many elbows, the next larger size pipe than that specified in Art. 39*a* should be used.

STEAM PUMP GOVERNORS AND AUXILIARY PUMPS

117. Where the automatic supply, other than steam fire pump, is of light pressure or limited capacity, such for instance as small or low gravity tank or poor water works system, it is often advisable to make the steam pump automatic and thereby the primary water supply.

118. Factors that make for automatic pump interruption include excessive wear, requiring comparatively frequent repairs, interruption of steam supply, and regulator troubles. While the record of the automatic pump has been good, it is not as satisfactory a primary supply as a water works connection, gravity tank, or pressure tank.

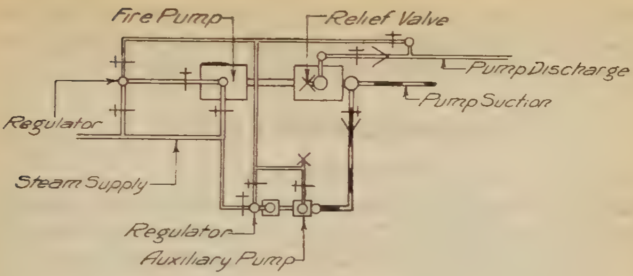
119. There are two ways of making a fire pump automatic; the one through the use of a pressure regulator which keeps the pump crawling to maintain desired pressure, and the other through the use of an auxiliary pump. In the latter case, both pumps have governors, but by setting the one on the auxiliary pump some 10 lbs. higher, the larger pump is stalled until a drop of pressure, such as produced by opening of a few sprinklers or turning on of a hose stream, automatically puts the big pump into service. The auxiliary pump supplies leakage in mains, ordinary waste, and maintains pressure. Fig. 46 illustrates three approved methods of connecting auxiliary pumps and governors.

120. To keep pump crawling causes excessive wear on the bronze bushed and rodded pump, and consumes, with a 1,000-gal. pump, several hundred dollars worth of steam per year. To use an auxiliary pump is better practice.

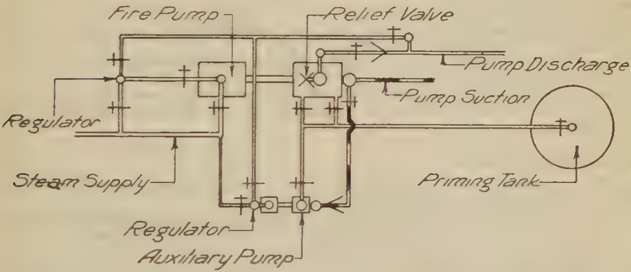
121. A governor is sometimes provided to run the fire pump at steady pressure at time of fire, but an attendant should always stand by a pump so operating.

122. Every governor on a fire pump should be placed on a bypass between two valves, a throttle valve giving control independent of governor.

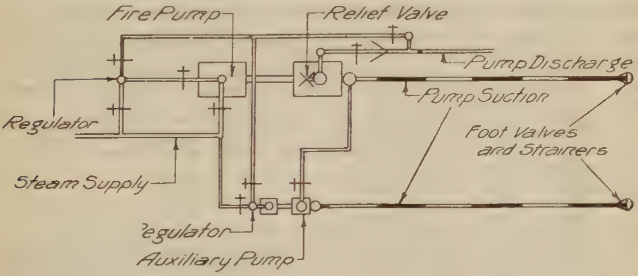
123. Numerous types of governors have been sold for fire pump service, some of which are not adapted to this use and naturally have been found wanting. Simplicity is of much value, as it tends to make the governor more reliable. Governors with



PLAN-A-For Pumps Taking Water Under a Head



PLAN-B-For Pumps With Lifts Not over 10'-0," Short Suctions, and no Foot Valves



PLAN-C-For Pumps, With any practical Lifts, Long Suctions, and Foot Valves

FIG. 46. APPROVED METHODS OF INSTALLING PUMP REGULATORS (GOVERNORS) UNDER VARIOUS CONDITIONS.

pistons and small ports are perhaps more sensitive than the simpler types, but are more likely to stick or fail to operate properly when suddenly called upon for heavy service.

NATIONAL BOARD RULES

(Edition of 1915)

124. The following extracts of the regulations of the National Board of Fire Underwriters for the installation and use of Steam Pump Governors and Auxiliary Pumps are reproduced as being of general interest.

GENERAL RULES.

Automatically controlled pumps are not acceptable as the sole primary water supply for automatic sprinklers.

Where there is a good gravity supply it is not advisable to equip the fire pump with an automatic governor.

Whenever it is necessary to use an automatically controlled pump an auxiliary pump should always be provided to maintain the pressure and supply leakage.

AUXILIARY PUMPS.

Auxiliary pumps should be of duplex type, brass fitted and with packed pistons or exterior packed plungers.

A 4½ × 2 × 4-in. pump has been used in many situations with good satisfaction. A 4½ × 2½ × 4-in. would probably answer equally well in most cases and have the advantage of some greater capacity. Where a larger capacity is needed, as in very large pipe systems, a 5¼ × 3 × 5 in. would be advised. These pumps are large enough to have good lifting ability and they are of sufficient capacity to take care of all ordinary leaks and wastes.

INSTALLATION OF GOVERNORS AND AUXILIARY PUMPS.

Pump governors and auxiliary pumps should be arranged in accordance with one of the three Plans, "A," "B" or "C," shown in Fig. 46.

This applies to the scheme of connections and number and location of valves, but not to the exact position of the auxiliary pump and connecting pipes.

The main pump and the auxiliary pump must have separate governors made entirely independent by a valve on the water connection of each.

The size of governors for the main pump should be as follows:

For 500-gal. pump, 1¼-in. governor.
For 750-gal. pump, 1½-in. governor.
For 1,000-gal. pump, 1½-in. or 2-in. governor.
For 1,500-gal. pump, 2-in. governor.

The size of the governor is restricted in this way in order that the pump may not run too rapidly for safety in the absence of an attendant, in case of an excessive demand for water, or of a loss of its suction supply. When, in case of fire, the attendant reaches the pump, it is expected that he will control it through the regular throttle valve. However, with the boiler pressures now common, these governors will run the pumps at good speed and often at full speed.

The governor for the auxiliary pump should be ⅜-in. connected into a ½-in. steam pipe.

A pipe larger than ½-in. is undesirable, as it would permit excessive racing of the small pump if the pressure in the main system were low.

A ¾-in. governor is required to get the working parts large enough to be reliable.

The auxiliary pump should have an independent exhaust.

If the auxiliary pump exhaust is connected into the exhaust of the main pump there is danger of water collecting in the large pump pipe and causing trouble.

The water pressure pipe controlling the governors must be of brass. It must connect beyond the main pump discharge check and must have control gates as called for in Art. 2.

Brass is required to avoid trouble from corrosion.

Lubricant must be applied so as not to pass through governors before entering pumps, unless manufacturers specify otherwise.

Unless the governors are designed for it there is danger of the oil gumming up the parts.

The governor for large pump to be installed on usual "three-valve" by-pass arrangement of steam piping.

This is shown in the cuts, a valve being provided on each side of the governor while the governor itself is on a by-pass around the main valve. This permits shutting off the governor for repairs and still have steam available on the pump through the main throttle.

The auxiliary pump should have a relief valve capable of discharging full capacity of pump without letting pressure rise more than 25 lbs. above that at which governor is set.

This is to prevent the small pump putting a dangerous pressure on the system. In some cases the large pump governor is also available for the small pump, but where this is not so a special governor must be provided for it.

Duplicate governors, or duplicates of wearing parts, should be kept on hand in all important installations.

This is to avoid delay in repairs.

The governor on the auxiliary pump should usually be set at about 10 pounds higher water pressure than the governor of the main pump.

This is to give some margin so that the large pump will not start with small changes in pressure.

An auxiliary pump will not operate successfully unless the water end stuffing boxes and joints and suction fittings complete of the main fire pump are in good condition. Further, there should be no serious leaks in any part of the fire system.

Under proper conditions the small pump will move slowly all the time, making just enough strokes to maintain the small leakage which exists in any considerable equipment. The large pump will remain quiet until there is a demand for water by sprinklers or hose streams.

FIRE DEPARTMENT CONNECTIONS

125. It is obvious that a private fire protection system in or adjoining a city should be designed to permit water from fire department steamers or gasolene pumping engines and through high pressure system hose lines to be supplied to such private protection. This is especially important where the private supplies are limited, as when secured from gravity and pressure tanks or from pumps drafting from reservoirs or suction tanks. The superiority of automatic sprinklers as a fire extinguishing agent over outside hose streams is so marked that even the city fire departments, which on the whole were slow to recognize the great value of sprinklers, now generally realize the advantage of connecting hose lines to fire department connections promptly upon arrival at the plant or building. A fairly common rule is that the second steamer or the second hydrant line shall be attached to such a connection. Nevertheless, a very large percentage of existing fire department connections are not used when an opportunity offers, and property owners should assure themselves that these connections are in order, that fire department officers know of their location, and that orders are issued to use them in event of fire.

126. It should be borne in mind that the automatic sprinkler is an exceedingly valuable aid in preventing conflagrations or spread of fire from one building to another. Exposure fires may open up a large number of sprinklers on account of unprotected wall openings, and in such cases more than ordinary water supplies are required.

127. Such connections should be located so as to be available in case of exposure fires. This will often mean having connections on two or more sides of a building, so that in case one street front is not accessible at time of fire, the fire department can connect up on another street.

128. The relatively small cost of fire department connections is an additional argument why they should be generally provided where there is public protection available.

129. The two forms of fire department connections now in use are the siamese connections and the pumping hydrants.

SIAMESE CONNECTIONS.

130. While fire department connections occasionally have three, four, and even six outlets, the double or siamese connection is commonly employed. These connections are almost universally used as a source of supply to a single building, and separate connections are commonly provided for automatic sprinklers, open sprinklers, and standpipe service.

131. Modern design of siamese connections calls for caps of the type that can readily be removed by breaking if necessary.

132. Section J of Sprinkler Rules, covering Fire Department connections, are as follows:

FIRE DEPARTMENT CONNECTIONS

(Automatic Sprinkler Rules—Edition of 1922)

67. Recommendations—In addition to the above required double supply, it is recommended that a siamese hose inlet pipe to sprinkler system be provided for connection from hose or steamer of public fire department.

68. Pipe Size.—Pipes size shall be not less than four inches for steamers and six inches for fire boat couplings, and each connection shall be fitted with a straightway check valve, but not with a gate valve. Siamese connections should be provided with check valves in the "Y."

Connections should be so located as to provide for prompt and easy attachment of hose.

69. Drain.—Each connection should be arranged to properly drain the piping between the check valve and the outside hose coupling, and a ball drip having a half inch pipe connection and a half inch orifice and a bronze ball of proper size should be provided and where necessary arranged to drain preferably to a sewer or other satisfactory place. See Fig. 119, page 573.

70. Where Attached.—To equipments having a single riser, attach on the system side of the gate valve in the riser for a wet system, but between the dry valve and the gate valve for a dry system.

To equipments having two or more risers attached on the supply side of the gate valves, so that with any one riser shut off the supply will feed all the remaining sprinklers.

Any underground pipe used to attach Fire Department connections to system should be cast iron, and the wrought and cast iron pipes should be properly strapped together.

All Fire Department connections should be so arranged that they have proper support.

71. Threads.—Each hose connection should be made of good bronze, having thread to fit coupling of public fire department. The body of the check may be of cast iron, provided the hose thread and that portion of the coupling upon which the swivel turns, and also the valve seats, be constructed of good bronze, and all properly secured. Standard cast iron, malleable iron or brass caps, properly secured, and arranged for easy removal by public fire department, should be provided in each connection.

Each hose connection should be designated by raised letters at least 1 inch in size, cast in the fitting in a clear and prominent manner and reading for the service designated, viz.: "Auto. spkr." or "Open spkr."

72. Number of Connections.—Should be specified in each case by the Inspection Department having jurisdiction.

PUMPING HYDRANTS.

133. To meet the situation of an underground fire system which may feed hydrants, sprinklers, and standpipes, being in turn supplied with water from public sources, there has been designed a pumping hydrant which is illustrated in Fig. 47. It can, of course, be used with or without a city water connection. The following is a description of this form of installation:

A is a pumping hydrant, being simply a siamese head on a vertical pipe. It can be located either at the curb or at the property line, whereas the ordinary siamese connection is attached directly to building wall. A hydrant with female threads could also be used.

B is a drain normally open, to prevent freezing of system in winter.

C is check valve in pumping connection.

D is repair valve, normally chained open, to enable repairs without cutting off city connection. Such a valve is forbidden by some insurance jurisdictions.

E is repair valve, normally open, to enable meter and city connection check valve to be worked on without shutting off pumping hydrant. An O. S. & Y. valve may be required on each side of meter.

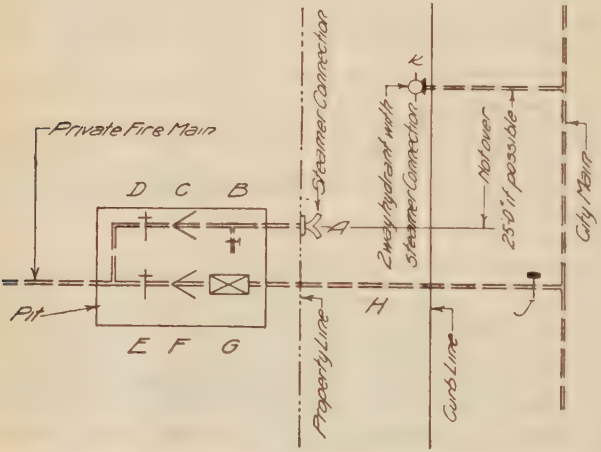


Fig. 47. Metered Water Works Connection to Private System with Fire Department Connection

F is city connection check valve working against private water supply. Double checks to prevent pollution can be used where necessary. See Fig. 40.

G is fire service meter, advisable if any form of meter is required.

H is city main connection laid in same trench with pumping hydrant line.

J is city valve at street main.

K is city hydrant with steamer connection, located, if possible, within one hose length of the pumping hydrant.

REQUIREMENTS FOR ELECTRICAL DRIVING AND CONTROL OF FIRE PUMPS

134. As indicated in section on "Centrifugal Pumps," electric drive for such pumps is now being used extensively, and it is entirely feasible to use motor drive for reciprocating or for rotary pumps.

135. Standard motors unquestionably are capable of reliable service in case of fire, providing their current supply is safeguarded and providing they are protected against leaks or spray from pumps or piping.

136. Generally speaking, overhead service through city streets or alleys to a city plant is not safe, and underground service, unless on a special line from a sub-station or power station, is not proof against interruption by fire in some other plant. Special overhead lines in districts where these will not be appreciably exposed, and particularly where there is a duplicate feed to the plant, may be entirely satisfactory.

NATIONAL BOARD RULES

(Edition of 1921)

137. The following extracts from the regulations of the National Board of Fire Underwriters for the installation of Electrical Driving and Control of Fire Pumps are of interest because general in character.

Before installing an electrically driven pump the matter should be taken up with the Inspection Department having jurisdiction in order that an investigation may be made to determine whether the reliability of the current supply is such as to make the electric service dependable.. The question of reliability of the service depends on so many factors that in many cases it can only be settled on the ground.

All details of construction, materials and apparatus pertaining to electrical equipment, except as modified or provided for by these requirements, must comply with the requirements of the National Electrical Code.

71. Power Station. *a*—When current is taken from a single power station the station must be of non-combustible construction, so located or protected as to be free from chances of serious damage by exposure from fire, and the design and arrangement of apparatus within it such that there will be but little chance of interruption of service.

b—Where current is taken through a sub-station, this sub-station must also meet the requirement of Section *a*, and in addition the number and arrangement of cables between the station and the sub-station must be such as to practically guarantee continuous power at the sub-station.

c—Where service cannot be obtained from a power station or sub-station meeting these requirements it must be obtained from two or more stations or sub-stations so located and equipped that an accident or fire at one will not cause an interruption of the service supplied by the others.

A private generating plant located on the premises served by the fire pump, if in a separate power house or cut off from main buildings, will be considered as a power station, and may be used as one source of current supply.

72. Transmission Lines. a—The lines between the power plants and the pump room must be of such number, so arranged and so located that there will be small chance of an interruption of service to the motor, due to accident to the lines. All wiring in the pump room must be in approved conduit.

Where the values involved are large and the crippling of this pump service would seriously affect the protection of the property, at least two separate lines from the power plant or plants to the pump installation must be provided. The lines must be run by separate routes or in such manner that a failure of both at the same time will be only a remote possibility.

Where current is taken from an underground Edison 3-wire system it will be considered that two independent lines have been provided if connections are brought into the pump room from two street mains or feeders not terminating directly in the same junction box.

A complete underground circuit from generating station to pump is strongly recommended and should be obtained when practicable. When such construction is not available, an overhead circuit may be allowed, but that part of the circuit adjacent to the plant or exposing plants must be run with special reference to damage in case of fire. Where the pump room is a part of, or in close proximity to, the plant which the pump is designed to protect, the wires for some distance from the pump room must be underground.

b—Each line between the power plant and pump room must be of such size that its safe carrying capacity, as given by Rule 18 of the National Electrical Code, will not be exceeded by the load carried.

Where direct current motors are used, the voltage at the motors must not drop more than 5 per cent below the voltage rating of the motors when the pumps are being driven at rated output, pressure and speed, and the lines between motors and power stations are carrying their peak loads.

When alternating current motors are used, the voltage at the motors under these same conditions must not drop more than 8 per cent. below the voltage rating of the motors.

c—The overload protective devices at the power plants, and where provided at various points on the lines, must be of such rating and so set that they will open the circuit only under short circuit conditions.

Approved fuses may be used, if desired, except for the protection of the pump motor where circuit breakers are required. The fuses, however, must be of such size that an overload or short circuit at the motor or its control apparatus will not cause them to open the circuit, but instead, the circuit breaker protecting the motor.

73. Transformers. *a*—Transformers must be located in a separate noncombustible, well-ventilated building or room thoroughly cut off from other buildings or rooms. Access to room must be from the outside of the building. Transformers may be located outdoors by special permission where conditions are favorable.

b—Transformers supplying current to the lights and motors in the buildings served by the fire pump may also supply the pump motor, provided all load except the pump motor load can be quickly cut off when necessary. Switches for doing this must be in the pump room unless transformer room is near pump room, in which case they may be in transformer room.

c—Room containing transformers installed solely for the purpose of supplying current to a pump motor must be dry and heated in cold weather, or else the transformers must be normally left connected to the supply lines.

74. Motors. *a*—Direct-current motors must be of the shunt or cumulative compound wound types. The speed of the motor at no load must not exceed the speed at full load by more than 10%.

Alternating current motors must be of the wound rotor or the squirrel cage induction type. The squirrel cage motor must not be used except when the conditions are such that it will surely start and attain full speed.

The above rule regarding alternating current motors will prevent the use of the squirrel cage motor with pumps of the positive displacement types, such as rotary and plunger pumps, and will require that the electric service be such that the heavy starting current will not cause the voltage to drop sufficiently to prevent the motor starting.

b—Motor must be of such capacity and design that at rated voltoge its full load ampere rating will not be exceeded when the pump it drives is delivering its rated output at specified pressure and speed and when running under this load continuously or until no further rise in temperature occurs. The rises in temperature at its various parts above the temperature of the surrounding air must not exceed 40°C except that the rise in temperature in the field of a D.C. motor may be as much as 50°C as permitted by the standardization rules of the American Institute of Electrical Engineers.

Motor designed for a temperature rise not exceeding 40°C when carrying its rated full load continuously must be able to carry an overload of 25% for two hours immediately following a full load run without a temperature rise at any part exceeding 55°C. Motor must be able to withstand a momentary overload of 50% without injury. No electrical or mechanical weakness should develop during these tests.

Note. For proper sizes of motors to be used with pumps of different capacities see Article 42.

c—Motor and control apparatus must be protected from water coming from possible leakage, or breakage of any connection at the pump or other piping in its vicinity, including hose lines which may be connected to the pump.

This can probably be best accomplished by the erection of a non-combustible partition between motor and pump, extending from floor to ceiling, and laterally sufficiently far to protect the motor and other electrical apparatus not otherwise protected. Such an arrangement will permit the use of the open type of motor, and for most situations will prove the least expensive. The enclosed type, with fan or blower system may be used, but preference is given to the arrangement described.

d Motor windings should be thoroughly impregnated with waterproofing compound.

e—Bearing shells and caps for motors must be of the split type on at least the driving end, to permit removal and replacement without disturbing the motor or shaft after installment.

This is important to permit quick overhauling in case bearing becomes heated or damaged after being assembled with pump on its bedplate.

138. The rules also go into minute detail regarding Controlling Equipments, both manual and combined manual and automatic types.

ROTARY FIRE PUMPS

139. The so-called rotary pump is one of the oldest types of fire pump, and is generally found in mills and factories driven by water power. It is simple in construction, cheap, but wasteful of power. It is generally of the double shaft or twin type, with cams or buckets which intermesh, pump being usually direct connected by a spur gear or gear clutch or by a friction gear. This class of pump, while as a whole giving fair fire service, has been more or less unreliable, due to rusting of the pump itself, breaking of the buckets, or trouble with friction or spur gears.

140. Other deficiencies have included pipe connections of insufficient size, generally weak construction, lack of air cushion chamber, and lack of relief valves and hose valves. Furthermore, these pumps are generally located in basements, not easily accessible at time of fire, and, as they frequently have little or no care, it is not surprising that they often fail when called upon.

141. Unquestionably, the use of the rotary form of pump is decreasing, and that of the centrifugal pump increasing. The standard rotary pump, however, properly installed and properly supplied with power, is a very efficient fire fighting device.

142. The location of the pump is of primary importance. It is only a makeshift to arrange the pump to control from the outside, when it is located in some inaccessible place. The pump naturally requires careful maintenance, frequent operation, and liberal oiling.

143. The power required to drive rotary pumps varies, but 30 h.p. per 250 gals. per min. at 100 lbs. pressure is believed to be a safe maximum.

CENTRIFUGAL FIRE PUMPS

144. The centrifugal pump is making rapid progress. It is especially adapted to direct connected electric and to steam turbine drive. It is found in service in city high pressure pumping stations, in water works, and in private plants for fire protection, as well as for domestic purposes.

145. Generally speaking, there is no occasion for using a motor driven centrifugal fire pump in a plant which generates its own steam supply, for the electric current is one step further away from the primary power supply, and the cost of a centrifugal pump and motor is about twice as great as that of a

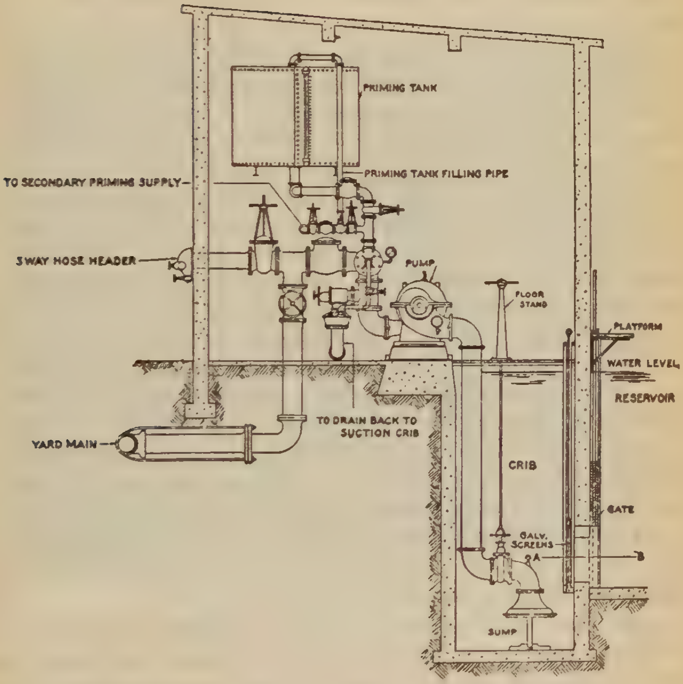


FIG. 48 CENTRIFUGAL PUMP WITH SUCTION CONNECTIONS
(Courtesy Factory Insurance Association)

duplex steam pump of equal capacity. The electrically driven pump appeals, therefore, primarily to those who purchase their power from a public utility, or who must locate their pumps at a water supply far from the boiler house.

146. Available field experience, the authors believe, warrants the statement that the best makes of centrifugal pumps are as reliable as steam fire pumps insofar as the water end is concerned, and that the chief problem which requires consideration is the safeguarding of the current supply in the case of electric pumps and the steam supply where turbine drive is used. The centrifugal pump has some real advantages over the underwriters' steam pump, such as smoothness of action and less danger of developing excessive water pressures. There are several makers of centrifugal fire pumps who furnish reliable apparatus, but the manufacture of these pumps has hardly reached the uniform excellence of the underwriters' steam fire pump. It is very advisable to purchase the pump and motor or steam turbine complete as otherwise there is divided responsibility. See Fig. 49 for illustration of a standard two-stage centrifugal fire pump. Single-stage high pressure pumps are also available for fire duty.

147. A centrifugal pump should preferably receive its suction under at least a slight head, as it is absolutely incapable of picking up suction without priming. See also page 350.

148. The section bearing on requirements for electrical driving and control of fire pumps, covers the electrical features of a centrifugal pump installation.

149. The power required to drive centrifugal pumps varies less than with rotary ones. 25 h.p. per 250 gals. per minute at 100 lbs. pressure is the usual figure given by manufacturers.

150. One excellent arrangement available in plants that have both domestic and fire pumps of the centrifugal type is to have the fire pump backed up by two lower pressure domestic pumps, placed in series at time of fire, which is readily possible through valve manipulation, providing one of the pumps has a casing strong enough to stand the higher pressure. The water supply for fire may, of course, be secured solely from moderate pressure domestic single-stage pumps placed in series at time of fire.

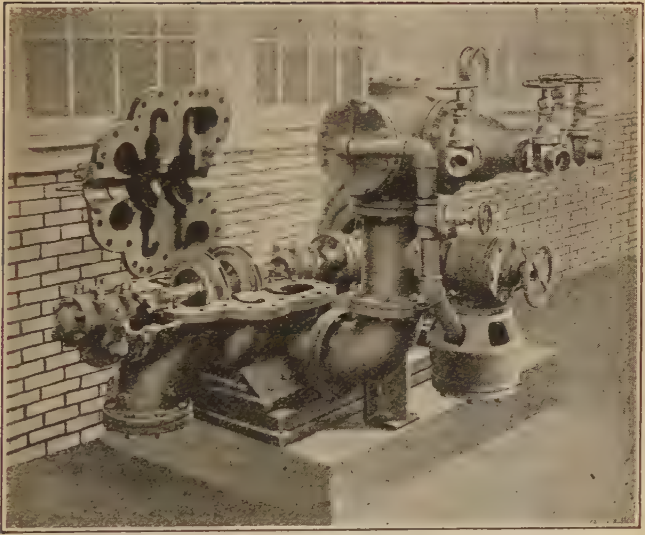


FIG. 49. TWO-STAGE CENTRIFUGAL FIRE PUMP
(Courtesy of The Goulds Manufacturing Co.)

151. Fig. 50 shows a model installation of this kind, and will bear careful study.

a—The plant is at Niagara Falls where unusually reliable electric current supply is available.

b—*A* and *B* are one stage 65 lbs., 1,350 gals. per minute centrifugal pumps, normally supplying the domestic system which is separate from the fire system.

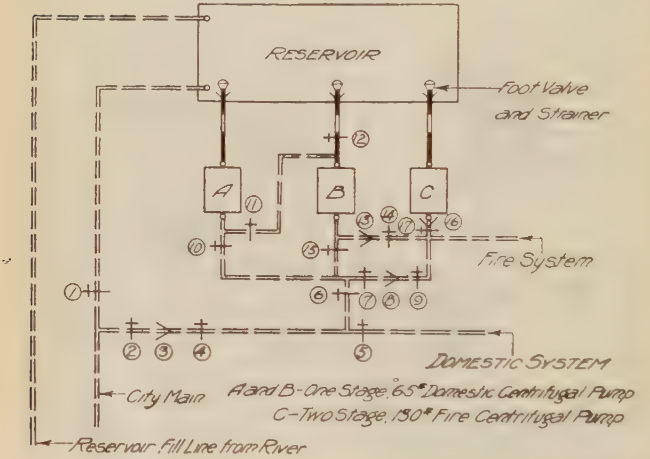

RESERVOIR
Foot Valve and Strainer
A
B
C
①
②
③
④
⑤
⑥
⑦
⑧
⑨
⑩
⑪
⑫
⑬
⑭
⑮
⑯
⑰
Fire System
Domestic System
City Main
Reservoir Fill Line from River
A and B - One Stage 65# Domestic Centrifugal Pump
C - Two Stage 130# Fire Centrifugal Pump

Fig. 50. Model Centrifugal Pump Installation.

c—*C* is two stage 130 lbs., 1,350 gals. Underwriters' pump reserved for fire duty.

d—All pumps draft from a reservoir which is filled by gravity line from river. Priming connections from city main and from domestic system are not shown.

e—In case *C* cannot supply enough water, *A* and *B* are thrown in series by closing valves 10, 12, and 15 and by opening 11.

f—Domestic pressure is ordinarily on fire system through valve 14.

g—Valve 1 is emergency fill connection for reservoir.

h—Valve 4 is ordinarily closed, but if opened, in conjunction with operation of valves 5 and 6, city main can be used to feed domestic system while *A* and *B* feed fire system, or feed fire system, or both systems at the same time.

i—Valves 1, 4, and 11 are ordinarily closed.

j—Valves 2, 7, 9, are required to permit check valve repairs and cleaning without affecting the balance of the system.

k—All valves are O S and Y type, in plain sight in fireproof pump room.

The important point is that, with almost no additional expense, it is possible through putting domestic pumps in series to secure a high pressure water supply.

NATIONAL BOARD RULES

(Edition of 1921)

152. The following extracts from the regulations of the National Board of Fire Underwriters for the installation of Centrifugal Fire Pumps are reproduced as being of general interest.

The commercial centrifugal pumps now in use for various purposes are of such different types and so often are weak in construction details, have small water passages, and have working faces of corrodible material, that for fire purposes it has been considered necessary to require improvements in these features in order to make these pumps satisfactory for the severe and peculiar conditions of fire duty. Pumps built in accordance with these specifications will have:

a—Rugged construction and ample strength in all parts.

b—Liberal water passages.

c—Working parts of non-corrodible material where exposed to corrosion.

d—Several special fittings, such as discharge casting, hose valves, capacity plate, pressure and vacuum gauges.

40. Stages.

The pump must be of not less than two stages and not more than four. To obtain a fire pressure of 100 lbs. two stages at least appear to be necessary, in order to avoid very large impellers and to secure a reasonably good efficiency.

41. Capacity and Speed.

(*a*) The four standard sizes for centrifugal pumps will be as follows:

Size of Pump	
Gals. per min.	**No. 1⅛ in. Streams**
500	2
750	3
1,000	4
1,500	6

(*b*) The speed of pump must not exceed 1,800 revolutions per minute. Centrifugal pumps will be most frequently driven by electric motors, and it is desirable to bring their speeds into conformity with the larger number of standard motors now being built.

Somewhat higher speeds, not to exceed 2,500 r.p.m., may be allowed for pumps driven by steam turbines. But in such cases permission should be obtained from the inspection department having jurisdiction.

Steam turbines must be capable of driving pump at rated speed and pressure, with steam pressures varying from 75 to 150 lbs.

42. Efficiency and Power.

The pump must be able to discharge its full rated capacity at its rated speed against 100 lbs. pressure, with substantially a zero suction lift, and at an efficiency not less than as given in the table following:

Size of Pump	Efficiencies
500 gals. per minute	50 to 55
750 gals. per minute	55 to 60
1,000 gals. per minute	60 to 65
1,500 gals. per minute	65 to 70

55. Suction and Discharge Openings.

(*a*) The openings provided in the pump casing for suction and discharge must not be less than as given below:

	Size of Pump (gals. per minute)			
	500	750	1,000	1,500
Suction Inlet....................	6 in.	8 in.	8 in.	10 in.
Discharge Outlet.................	6 in.	8 in.	8 in.	10 in.

61. Gauge for Suction Inlet.

A compound pressure and vacuum gauge must be provided and connected to suction pipe near entrance to pump.

INSTALLATION OF CENTRIFUGAL PUMPS

69. Driving Connections.

Centrifugal pumps will probably be driven by electric motors in most cases, though any reliable form of prime mover may be adapted to the service. The preference will naturally be for such driving methods as permit of a direct connection without speed-changing devices. With motor driving the main question will be the reliability of the current supply, and this can be determined only by a careful study of the conditions in each case.

Where the speed of motor or prime mover is not the same as pump speed, the transmission may be either by a single pair of cut spur gears, preferably of the herring-bone type, or a silent chain drive of approved construction.

70. Tests for Acceptance.

(*a*) The pump must be able to discharge its full rated capacity at 100 lbs. pressure at the pump, assuming a zero suction lift, and maintain this condition indefinitely without objectionable heating of bearings or at motor, or exceeding the rated power of the motor and with an efficiency not less than specified in Article No. 42.

(*d*) If provision is made for varying the speed of the motor, try the motor at different speeds under conditions which would be likely to be met with in case of fire, noting quantities and pressures, and compute efficiencies. Under all conditions the motor and pump should run smoothly and without trouble in any part which would prevent continuous running, should occasion require it.

(*e*) Let all water out of the suction pipe, note the lift, and make several tests to determine how long it takes the priming apparatus to get the pump again into service. Especially note whether the pump shows any sign of heating or other distress where the priming equipment requires it to be run a short time before it is flooded with water.

STEAM TURBINE DRIVEN PUMPS

153. The 1923 N. F. P. A. Proceedings contain the tentatively adopted rules for the use of steam turbines for driving centrifugal pumps. The essential points are:

a—Reliable steam supply, adequate to operate pump at 25 per cent. above rated capacity with 80 lbs. steam pressure at the throttle.

b—Maximum speed of 2500 R.P.M., governor to control within 5 per cent. of rated speed, and independent emergency governor set 20 per cent. above rated speed.

c—Substantial bed-plate for pump and turbine, and great care to secure alignment to avoid heating of bearings.

GASOLENE ENGINE DRIVEN PUMPS

154. The reliability of modern gasolene engines as regards starting and continuous running makes them available as a sole source of power for centrifugal pumps or as a stand-by for steam turbines or electric motors where these do not have entirely reliable sources of power. Gasolene drive is not considered the equal of steam or electric drive taking power from well guarded sources. The 1921 National Board regulations give details regarding all essential matters, pertaining to engines, power, speed, fuel, and ignition. Items of interest to the man in the field are:

In view of the character of the gasoline fuel these equipments should not be installed in depressed pump rooms.

96. Engine.

a—Engines for fire pump service must be of the four cycle type, and must be specially rugged and reliable. They must be at least the equivalent in all essential respects of the best grades developed for high speed motor boats.

b—There must be provided a self-starting arrangement operated by a storage battery of ample power and also a manual starting arrangement to be available in case the self-starting arrangement is out of order. Means for recharging the storage battery must also be provided.

Sufficient storage battery capacity must be provided to operate the starter continuously with spark and gas shut off for a period of 2½ minutes.

d—The lubrication for main and crank bearings must be of the force feed type employing a hollow crank shaft, not depending upon the splash of cranks for oil distribution. Easy access must be provided for the oil strainer and a sight feed or oil pressure gauge provided where it can be readily seen.

A reliable indicator should be provided to show the quantity of oil in the crank case.

For the lubrication of piston and wrist pin, dependence is placed upon the splash system.

e—There must be two separate systems of electric ignition, one of which must be of the magneto type. The two sets of spark plugs must be fitted for each cylinder and the ignition systems so arranged that the motor can be started and run from either.

97. Power.

b—Engines must develop at least the power shown by the following table:

Gallons Per Minute	Required Power of Engine at Normal Rated Speed
500	75 Horse Power
750	100 Horse Power
1000	125 Horse Power
1500	168 Horse Power

Until an engine be developed closely fitting the 750-gallon pump, it will be necessary to use the engine for the 1000-gallon pump outfits. Under these conditions, the cost of the 750-gallon pump and engine will be so near the cost of the 1000-gallon pump and engine that purchasers will find it to be an economic measure to buy the 1000-gallon pump outfit in lieu of the 750 gallon.

c—The engine must be directly connected to the pump without any reduction gearing or belting. For special cases where displacement pumps are used, requiring a lower speed, the engine may be connected to the pump by means of a helical gear or a silent chain drive of ample capacity. The pump shaft should be connected to engine shaft by means of a flexible coupling of suitable design.

98. Speed.

a—The normal rated speed, with present construction, will ordinarily be 1200 R.P.M. and the maximum speed should never exceed 1500 R.P.M.

b—A governor must be provided for engine capable of adjustment between the speeds of 500 and 1500 R.P.M.

c—The engine must be capable of running indefinitely at the rated speed of pump and have a range of speeds varying from about 50% of the normal speed to about 25% above the normal speed. It should do this without undue heating or other trouble.

d—A suitable speedometer should be provided and connected permanently to the engine to show instantly the speed at which the engine is operating.

99. Engine Details.

b—Adequate means of quickly and effectively priming the engine must be provided. A suitable gasoline strainer so located as to be easy to clean and replace must be furnished with engine and connected close to the carburetor. A suitable flexible gasoline tube connection to the carburetor must be provided with the engine.

h—A complete and durable book of instructions for the care and operation of the gasoline engine and its accessories must be furnished with the engine.

102. Gasoline Supply.

a—The main gasoline supply tank should provide sufficient storage capacity for at least 36 hours' supply for the engine at rated load. It should be located outside the pump room and in accordance with municipal ordinances and requirements of inspection departments having jurisdiction. Means must be provided for determining the amount of gasoline in the storage tank. The tank should have standard fill and vent connections.

Allow one pint of gasoline per horse power per hour. For a 1,000-gal. pump this would mean about 500 gallons.

107. Maintenance.

Gasoline engines necessarily embody moving parts of such design and in such number that they cannot be relied upon to give reliable service unless given intelligent care. The manufacturer's instruction book covering care and operation should be preserved and pump operators should be familiar with its contents and should observe in detail all of its provisions.

a—The engine and pump should be started as often as once a week and run sufficiently long to make sure that the pump has its water and pressure is raised and the engine and pump are running smoothly at rated speed.

b—Keep gasoline storage tank well supplied. This tank should always be filled through a strainer funnel designed to withhold any water or other foreign matter that may be present in the gasoline.

The service tank should also be kept full.

c—Keep the engine clean and dry and well lubricated.

d—The storage battery should be kept charged at all times and tested frequently with a hydrometer to ascertain the condition of the cells and the amount of charge in the battery.

e—Distilled water only should be used in storage battery cells and the plates should be kept submerged at all times.

f—The pump room must be maintained at all times above the freezing point.

g—Maintain plenty of oil in the crank case and substitute new oil when it has become fouled or appreciably thicker.

h—Keep two or three good extra spark plugs on hand.

BOOSTER PUMPS

155. Automatically controlled electrically driven centrifugal pumps. often termed "booster pumps," may be used as a means of providing a satisfactory automatic water supply for sprinkler systems, when the city supply pressure is inadequate for direct use. In several of the largest cities, pressures will not even take care of three- or four-story buildings. A booster pump can be used in connection with tanks, or as a single supply in place of gravity or pressure tanks. The electric supply for such an installation should be safeguarded as set forth previously in this chapter.

156. In many sections of our cities there is ample capacity and sufficiently large mains to give plenty of water for sprinklers, but the pressure is weak. The "booster pump" draws water from these low pressure mains and automatically raises the pressure 50 or 100 pounds or whatever may be needed. A "single-stage" pump will give about 50 pounds increase in pressure over the pressure in the city mains, and a "two-stage" will give about twice that increase These pumps are equipped with an electrical self-starting device set to start the pump at some predetermined pressure. the regulator being connected directly to the sprinkler system When the pressure in the sprinkler system is reduced say 20 pounds below the normal working pressure of the pump, as for instance when a sprinkler operates, the pump starts, raises the pressure to the working pressure, and maintains approximately that pressure up to the capacity of the pump.

157. The record of automatic centrifugal pumps has not been

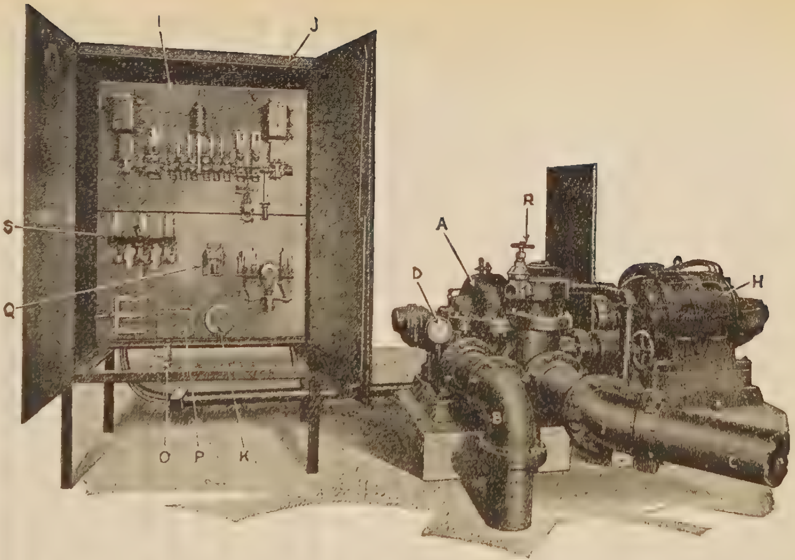


Fig. 51. Booster Pump, Connections and Control
(Courtesy The Grinnell Company, Inc.)

A, Centrifugal pump driven by electric motor H. B, Connection to low pressure city main. C, High pressure discharge to sprinkler system. D, Pressure gage on city water, supervised. K, Pressure regulator connected direct to sprinkler system. This actuates the starter I at top of control panel. O, Test valve operated by small electric motor in P and controlled from central station.

wholly satisfactory owing to lack of proper care, but the design of the pumps and automatic devices has improved, and reliable equipment is now available. The most radical development, and one which tends to place the automatically controlled electrically driven centrifugal pump on a par with other automatic water supplies, has been the application of central station supervisory service to this device. The Grinnell Company, Inc., has developed a method of supervision and test for booster pumps in conjunction with the A. D. T. supervisory service so that all important features in connection with the booster pump are under automatic supervision, and the pump itself can be actually tested from the central station as frequently as may be desired and as completely as if an inspector visited the property.

158. A ' Booster pump " supply is equally applicable to wet and dry systems. The advantages of such a supply are:

a—A high working pressure at the sprinkler.
b—Unlimited supply of water at sustained heavy pressures.
c—Suitability for old and weak buildings without structural changes.
d—Absence of tanks to be maintained, heated, and kept filled.
e—Absence of unsightly structure on roofs or in yards, with the attendant danger due to the enormous weight of such water tanks.

159. The first completely supervised booster pump used as a single supply to automatic sprinklers was installed in New York City, in 1920. Fig. 51 shows a pump of this character with panel board, electric starting device, test valve, etc.

GRAVITY TANKS

160. The elevated **wooden gravity tank** is one of the oldest and most common water supplies for automatic sprinklers. Its cheapness and simplicity appeal to the property owner, and we still find in service many old tanks of small capacity, often hardly more than tubs, located in towers or over roofs only a few feet above the top sprinklers. Such a supply is woefully inadequate, especially when compared to the modern steel gravity tank of from 25,000 to 100,000 gals. capacity, located on steel trestle with bottom of tank 25 to 50 ft. above the top sprinklers.

These large tanks are becoming common and frequently are used to supply hose service as well as sprinklers. Furthermore, the steel construction and location away from the building tend toward safety.

161. Many **wooden tank collapses** have taken place due chiefly to corroding of hoops and sometimes to weak construction. These collapses frequently cause heavy property damage and sometimes loss of life. New round hoops (of proper size and spacing, according to the rules) will obviate the first mentioned danger. The flat hoop corrodes on the inside, frequently becoming very thin before being noticed.

162. Wooden tanks, of any appreciable age, need careful inspection to detect indications of rotting. Generally, inability to keep joints tight may be an indication of such trouble. Some competent judges feel that a wooden tank after fifteen years' service is ready to be replaced.

SIZE OF TANKS.

163. As pointed out on page 310, "**Necessary Capacities,**" the size of the tank will depend on the conditions in each case, but, to be on the safe side, it is well to have tanks of liberal capacity, and from the commercial side this class of water supply is economical. Ten thousand gallon tanks are now generally considered the minimum, even for small risks, and 20,000 to 25,000 gal. tanks are probably more common today than 10,000 gal. tanks were twenty years ago. The simplest rule is to have a tank as large as is reasonable when considering the size of the plant, cost of equipment, and other features, at the same time using as a basis the probable maximum number of sprinklers that will be opened in any one fire and the length of time that these sprinklers must be fed by the tank in order to be sure of controlling the fire.

ELEVATION OF TANKS.

164. As indicated on page 309, "**Necessary Pressures,**" the elevation of tank should be such as to give a good working pressure on the top line of sprinklers with several sprinklers operating. This would generally mean a static pressure of not less than fifteen pounds, and, taking into consideration the height of tank, this would necessitate that bottom of tank should be not

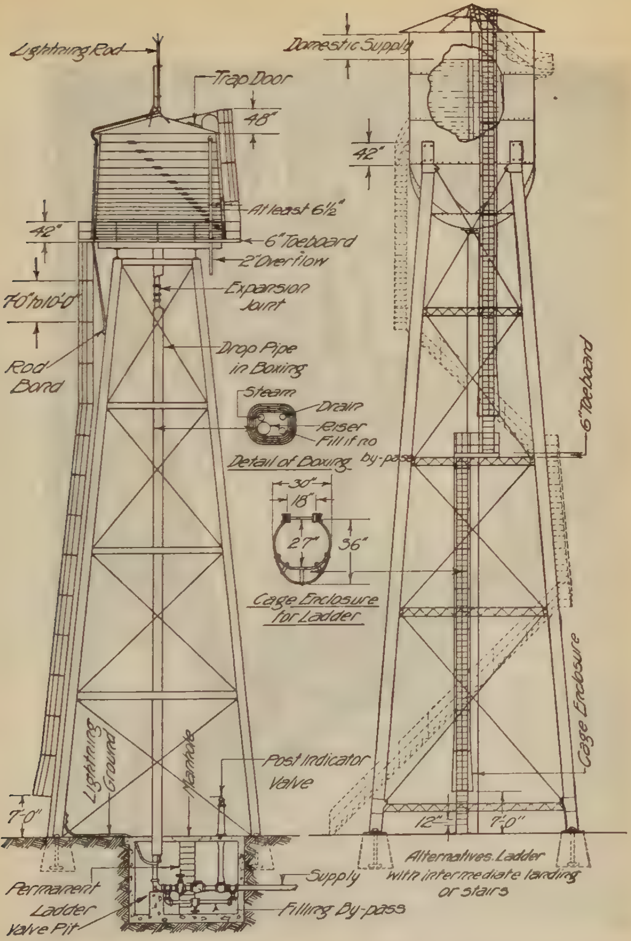


FIG. 52. GRAVITY TANKS, WOODEN AND STEEL ON STANDARD TRESTLES. Showing Properly Safeguarded Ladders, Stairs, and Platforms.

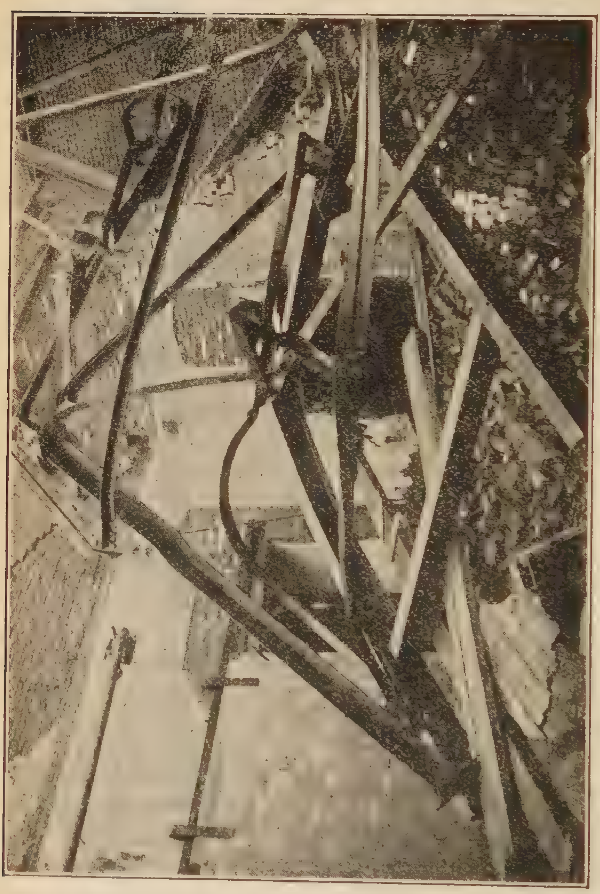
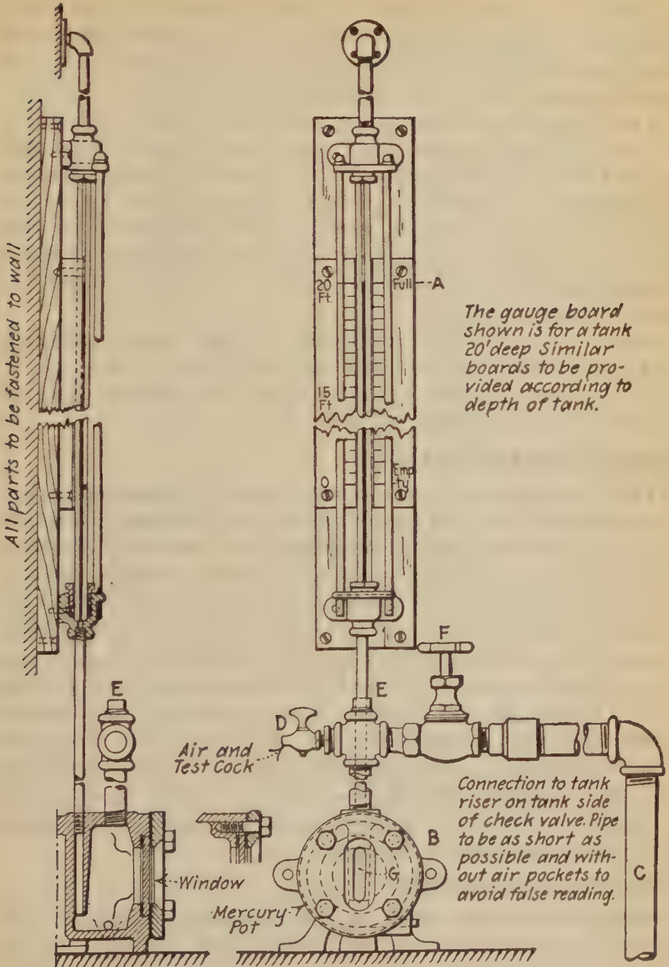


Fig. 53. Gravity Tank Trestle Collapse.
Illustrating danger of tanks above buildings.



The gauge board shown is for a tank 20' deep Similar boards to be provided according to depth of tank.

Connection to tank riser on tank side of check valve. Pipe to be as short as possible and without air pockets to avoid false reading.

FIG. 54. MERCURY TANK LEVEL INDICATOR.
(Courtesy Associated Factory Mutual Fire Insurance Companies.)

less than 25 ft. above top line of sprinklers, which is a very good minimum requirement. Elevation is even of more importance than capacity, for it is absolutely essential for the first few sprinklers that open to have a good working pressure.

165. General specifications have been drawn up by the underwriters for **steel tanks** Such tanks can be purchased and erected through or by reputable contractors. Elevated **tanks of concrete** construction have been used in a few cases and appear to have considerable merit. Reinforced concrete is used for the construction of both tank and trestle, and while the initial expense may be more than for the steel tank, the maintenance expense should be less.

166. The National Board Rules now bar gravity **telltales,** and make a mercury gage indicator practically a requirement. See Fig. 54. Approved sprinkler supervision devices are also accepted. See page 484.

INSPECTION OF TANKS.

167. Good practice requires that tanks be **inspected** at frequent intervals for such items as water level, freezing, corrosion, decay, and condition of telltale, which device will of course continue in service on a large number of tanks. Weekly climbing of the tank trestle is often the rule. The danger of this operation, especially under sleet, snow, and wind conditions is frequently acute. The matter has been referred to specifically in the chapter entitled "Relation of Accident Prevention to Fire Prevention." Figure 52 shows proper safety provisions for wooden tanks, requiring platform, and for steel tanks not necessarily requiring platform. The illustration also shows the essential fire protection features. It also shows the use of the upper portion of the tank for domestic purposes, a practice not advisable where water carries appreciable sediment.

HEATING OF TANKS.

168. Exposed tanks used for fire protection purposes in cold climates always require heating, even where a portion of the tank is used for domestic supply purposes. It has been customary in years gone by to use a brass coil in the tank or to discharge steam into the water. More recently the practice has been to use a special tank heater (generally employing steam) connected at

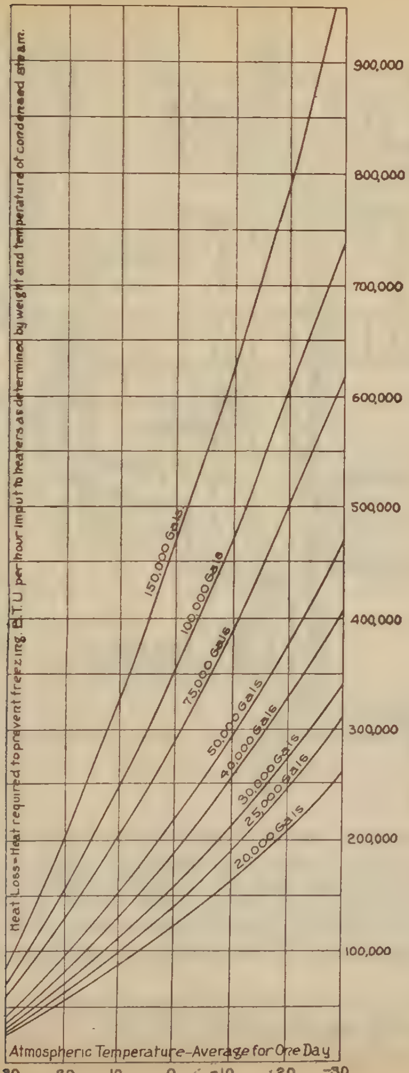


FIG. 55. HEAT REQUIRED TO PROTECT STEEL TANK AGAINST FREEZING

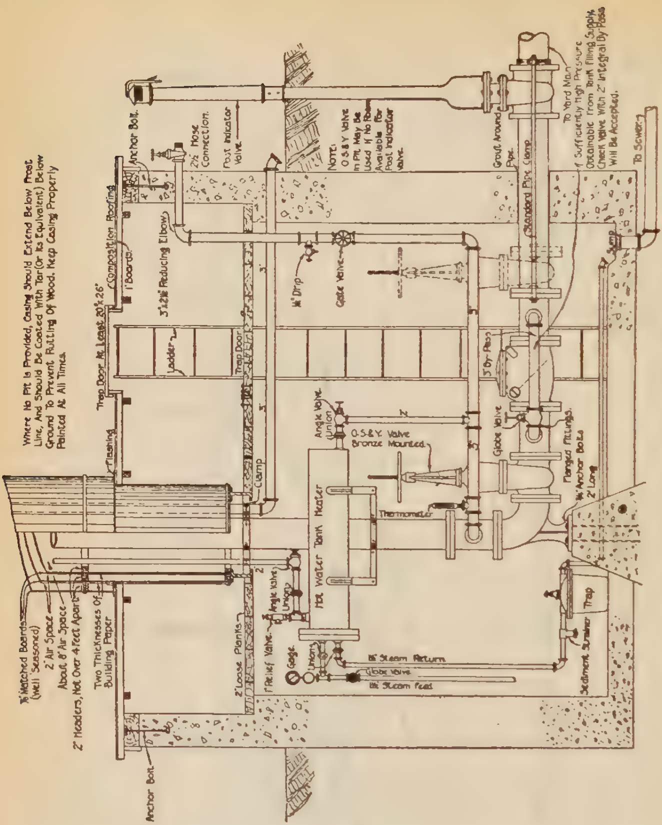

Where No Pit Is Provided, Casing Should Extend Below Frost Line, And Should Be Coated With Tar (Or Its Equivalent) Below Ground To Prevent Rotting Of Wood. Keep Casing Properly Painted At All Times.
⅞ Matched Boards (well Seasoned)
2' Air Space
About 8' Air Space
2' Headers, Not Over 4 Feet Apart
Two Thicknesses Of Building Paper
Anchor Bolt
Flashing
Trap Door At Least 20"x26"
1' Boards
Composition Roofing
Anchor Bolt.
2½ Hose Connection.
3"x2½" Reducing Elbow
Ladder
Post Indicator Valve
Trap Door
2' Loose Planks
Clamp
1' Relief Valve.
Gage
Union
Angle Valve
Union
Hot Water Tank Heater
Angle Valve
Union
O.S.&Y. Valve Bronze Mounted
¾' Drip
Gate Valve
Note: O.S.&Y. Valve in Pit May Be Used If No Room Available For Post Indicator Valve.
¾' Steam Return
Globe Valve
¾' Steam Feed
Thermometer
3' By-Pass
Globe Valve
Flanged Fittings.
¾' Anchor Bolts 2' Long
Grout Around Pipe.
Standard Pipe Clamp
To Yard Main
If Sufficiently High Pressure Obtainable From Tank Filling Supply Check Valve With 2' Integral By-Pass Will Be Accepted.
To Sewer
Sump
Sediment Strainer
Trap

Fig. 56. Pit under Gravity Tank Tower, showing Valves and Heater (Courtesy Factory Insurance Association)

the base of the riser. See Fig. 56. The October, 1922, Quarterly of the N. F. P. A. contains an illustrated article on "Heating Elevated Steel Sprinkler Tanks," which records tests from 1917-1922 made by the Factory Mutual Laboratories. Fig. 55 gives the results of these tests. The following is an explanation of the chart:

a—Determine lowest average Fahrenheit temperature for one day in locality in question.

b—Follow vertically on corresponding temperature line to proper tank size, and read at right the B. T. U. required per hour to keep water at 40° F.

c—Select a tank heater capable of providing required heat units, taking into account temperature of steam (related to pressure) and weight of steam condensed.

d—Riser's require effective frost-proof boxing, which must be well maintained. Dry rot is especially to be feared.

169. Figure 53 shows sprinkler tank trestle which collapsed owing to structural weaknesses and which caused serious building damage.

NATIONAL BOARD RULES

(Edition of 1919)

170. From the National Board Rules giving details of construction, installation, and use of Gravity Tanks, both wood and steel types, the following have been selected as bearing on installation and maintenance.

WOODEN TANKS

1. Size.

(*a*) The standard sizes of wooden tanks for fire protection are from 10,000 to 50,000 gals. capacity, although they are sometimes made larger.

(*b*) The capacity of the tank should represent the volume of water available for fire service and is to be the computed volume between the maximum water level and the outlet level.

3. Material.

White cedar, cypress, white and red pine, Douglas or Washington fir (Oregon pine) or Redwood must be used. Lumber must be free from sap, loose or unsound knots, worm holes and shakes; and be thoroughly air-dried.

Climatic conditions should be considered in selecting the most desirable wood for any location.

5. Hoops.

(*a*) The hoops must be round in cross section.

(*b*) The strength of a tank depends chiefly on its hoops. Experience shows that flat hoops, especially those of steel, rust from the back side where they bear against the staves, and serious accidents have happened by hoops bursting on account of the unobserved corrosion.

(*c*) There must be no welds in the hoops. Where more than one length of iron is necessary, lugs must be used to make connections, and the several pieces constituting each hoop must be tied together for shipment.

10. Hatches.

(*a*) Hatches must be provided in both the conical and flat covers so as to give easy access to the interior of the tank. The hatch covers must be beveled so they will not bind when swollen from dampness, and the hinges and fastenings must have bearings of non-corrodible metal such as brass. The covers must make a tight joint at the hatch edges, the one in conical roof to have edges turn down over raised edges of hatch.

(*b*) Hatch to be located preferably on southern side of tank and must not be less than 20 × 24 ins., inside measure, in size.

11. Supports.

(*a*) The weight of the tank must be supported entirely from its bottom; and in no event should any weight come on bottom of staves.

(*b*) There must be a clear space of at least 1 in. between bottom or outside of staves and balcony when used.

(*c*) All steel grillage must be used to support tank as called for in 48*a*.

(*d*) Tank must be securely fastened to trestle so that it will not be blown off when empty.

12. Discharge Pipe.

(*b*) The size of discharge pipe should not ordinarily be less than 6 ins. In small equipments with a short run of pipe a 4-in. or 5-in. pipe may be used. For sizes 20,000 to 75,000 gals. inclusive an 8-in. pipe is suggested, and for sizes over 75,000 gals. a 10-in. pipe.

(*c*) The pipe should preferably leave the tank bottom at its center.

(*d*) When the pipe drops vertically to the ground level the pipe must be supported on an underground elbow having a foot piece resting on a concrete foundation, and the elbow should preferably be flange-concreted to the underground pipe. If bell and spigot connection is used the joint should be strapped.

13. Filling Pipe.

(*a*) Filling pipe must be at least 1½ ins. diameter.

(*b*) When tank is exposed to the weather, the pipe must be carried up inside the frost-proof casing and extend through tank bottom to discharge at top of tank above water level. The portion of pipe inside tank must be brass. The pipe may be run up outside of tanks located inside buildings.

(*c*) Large tanks, particularly those located at some distance from the source of supply, may be filled through a by-pass, around check valve not less than 2″ or larger than 3″ in diameter. An approved globe, outside screw-and-yoke or post indicator valve, ordinarily kept closed, to be provided in the by-pass.

14. Drain.

(*a*) An approved 2-in. outside-screw-and-yoke gate or globe valve must be provided on nipple connected to base of discharge pipe to drain tank and discharge pipe.

(*b*) A suitable outlet must be placed in tank bottom to drain the settling basin.

15. Expansion Joint.

(*a*) When a tank is supported by a structure 30 ft. or more in height, whether on the ground or on a building, an expansion joint must be provided in the discharge pipe at the tank connection.

In cases where a tank is located in a heated enclosed tower, or in other places not subject to freezing, a four-elbow swing joint may be used with permission of inspection department having jurisdiction.

17. Heating.

(*a*) Arrangements must be made to warm the water in tanks where subject to freezing. The temperature of the water should not be allowed to reach the freezing point or go above 70° F.

The following heating methods are acceptable:
a—Circulation of warm water.
b—Steam coil.
c—Steam jet.

18. Frost-Proofing for Pipes.

(*a*) The discharge and hot water or steam pipes, and separate filling pipe when one is needed, for a tank on a tower on the ground or roof of a building, must be protected from freezing by a frost-proof covering in addition to having the water in the discharge pipe heated.

The frost-proof covering should not be depended upon to prevent freezing of the pipes without some heat being added. Most tanks for fire protective purposes have no draft from them except in case of fire, therefore the water in the discharge pipes has little or no circulation. For this reason, these pipes need more thorough protection than do pipes in similar positions which discharge from tanks in which there is nearly constant circulation, as for example in a village supply. Therefore the amount of protection to be provided for a certain pipe must be decided with due regard to the severity of exposure to cold winter winds, frequency of circulation in the pipe and amount of heat to be supplied.

The standard frost-proof boxings are made of wood and are circular or square in section as shown in Fig. 52.

19. Gauge.

(*a*) An approved form of telltale for showing the height of water in the tank must be provided.

(*b*) The following telltales are acceptable.

a—Approved sprinkler supervisory device. (Signaling Rules.)
b—Mercury gauge.

(*A*) As this gauge is connected to the yard pipe it is a separate fitting which is not furnished by the tank builders unless definitely included in their contract. The gauge will usually be furnished by the sprinkler contractor who installs the riser pipe, although it may be installed by the owner if desired. Mercury should be filtered.

(*C*) The gauge must be installed in a convenient, warm, inside location so that the graduated board will be in plain sight for reading, and the mercury pot easily accessible for maintenance.

20. Ladders.

(*a*) A steel ladder must be provided on the outside of the tank, extending to the top, so as to afford easy access to the hatch in the tank roof.

(*b*) The ladder must be constructed with not less than 2 × ½-in. flat side bars, spaced not less than 14 ins. apart, and supported at intervals of not over 10 ft. Rungs must be square, with corners pointing up and must be not less than ⅝-in. square. They should be spaced 12 ins. apart. The rungs must be riveted through slotted holes in the side bars to prevent their turning.

(*c*) Ladder must be secured to steel grillage or balcony supports by flat bar brackets in such a way as to properly support the weight of the ladder and 1,000 lbs. in addition. Ladder must at least be 6 ins. from side of tank.

(*d*) The ladder must extend about 18 ins. above the side of tank, then arch downward to the cover to form a handrail, as shown in Fig. 2, so that a man standing near its top can readily reach up and open with his right hand the hatch cover in tank roof. The handrail should be made of not less than ⅝-in. round rod.

Authors' Note—Better practice is shown in Fig. 52.

(*e*) A substantial wooden ladder must be provided inside of the tank extending from the trap-door to bottom of tank. Must be made of at least 2-in. by 4-in. side pieces and 1-in. by 2-in. cleats securely set in and spiked to the side pieces.

21. Lightning Rods.

Wooden or concrete tanks in locations subject to thunder storms must be equipped with lightning rods. These must be installed according to the regulations of the National Board of Fire Underwriters.

STEEL TANKS ON TRESTLES

22. Size.

(*a*) The usual sizes of steel tanks for fire protection are from 20,000 to 150,000 gals. capacity although they are sometimes made larger.

35. Painter's Trolley.

Some reliable form of trolley or other acceptable device must be provided to facilitate repainting of the tank.

CARE OF TANKS

39. General.

(*a*) Tanks for fire protection should not be used for other purposes except with the permission of the inspection department having jurisdiction.

The practice of using a foot or so of water for mill purposes from the top of a tank is objectionable; because when so used the tank collects a larger amount of sediment from the water which is constantly being supplied than it does when used for fire service only. This sediment is likely to settle in the sprinkler pipes, and either to clog them completely, or, in case sprinklers open, to seriously interfere with their discharge. If water is drawn from the bottom for mill purposes, the tank may, of course, be empty when needed for the fire service. Furthermore, the fluctuation of water level is liable to result in shrinkage of the upper ends of the staves, and leakage.

Where water is clean and without sediment, part of the tank may be used for domestic purposes with permission of the inspection department having jurisdiction.

(*b*) Tanks should be thoroughly examined at least twice a year to see that they are in good order.

(*c*) The sediment which collects in the tank bottom should be cleaned out when it reaches the top of the expansion joint casting.

(*d*) Examine flat hoops on old tanks very carefully to see if they are rusting from the back. If they are found to be corroded so as to materially weaken them, the tank should be strengthened by placing new hoops of round iron between the flat hoops, or by replacing the flat ones with round hoops of proper size and spacing.

TANKS ON BUILDINGS

(*a*) Tanks should be located on buildings only when this is absolutely necessary, as tanks so located are a menace to life and property unless the best of care is taken regarding the supports.

(*b*) Before supporting a tank on a building great care should be taken to make sure that the building is strong enough to carry the extra weight that the tank imposes.

(*c*) In a building about to be erected special arrangements for the tank should be made in the plans of the building itself. With buildings already constructed it is necessary to have an expert pass on the strength of the supports. It will often be desirable to arrange for the required capacity by two tanks instead of one.

(*d*) Tanks on buildings should be supported either by steel beams laid across brick, stone or concrete walls, carried above the roof to the necessary height or by a substantial trestle of the necessary height built in accordance with preceding rules so far as they apply.

PRESSURE TANKS

171. The advantage of an automatic heavy pressure water supply for sprinklers has been amply demonstrated. In most cases pressure is more important than volume, and the fire record shows that under ordinary conditions fewer sprinklers are opened and the fire is more certainly controlled where the sprinklers are fed by water under heavy working pressure. The pres-

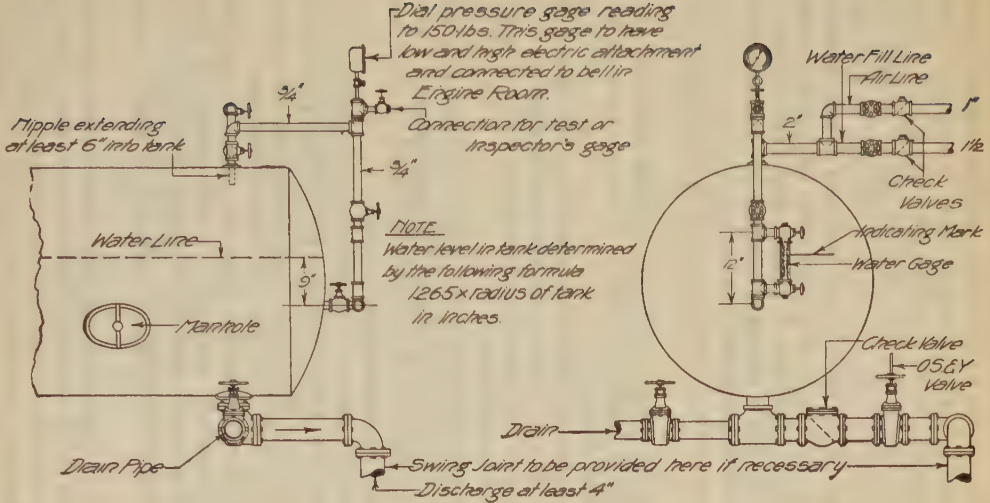

Dial pressure gage reading to 150 lbs. This gage to have low and high electric attachment and connected to bell in Engine Room.
3/4"
Nipple extending at least 6" into tank
Connection for test or Inspector's gage
3/4"
Water Fill Line
Air Line
1"
2"
1½
Check Valves
NOTE
Water level in tank determined by the following formula 1265 x radius of tank in inches.
Water Line
9"
Manhole
Indicating Mark
Water Gage
12"
Check Valve
OS&Y Valve
Drain
Drain Pipe
Swing Joint to be provided here if necessary
Discharge at least 4"

FIG. 57. PRESSURE TANK INSTALLATION.
(Courtesy of New York Fire Insurance Exchange.)

sure tank gives a limited supply, initial pressure of not less than 75 lbs. It consists of a cylindrical steel tank, usually placed horizontally, and located in the upper story or on roof of building. Its capacity varies from 4,500 gals. to 9,000 gals., or even more. It is kept two-thirds full of water, the other one-third being air under pressure, and the rules require that this air pressure shall be such that there shall be not less than fifteen pounds static pressure on top line of sprinklers when last water is being discharged. This means that if tank is lower than top line, more than 75 lbs. must be carried, which can be calculated according to a definite rule given later on.

172. Some of the advantages of the pressure tank are as follows:

a—It can be located inside the building, generally on floors already constructed, as it is not excessively large or unduly heavy.

b—The danger of freezing is minimized, for even if located on the roof it can be enclosed and heated.

c—Being air-tight, there is no evaporation and it should not need frequent filling.

d—If properly constructed and installed, the air pressure need not be pumped up oftener than once or twice a month.

e—The original cost is not high, and there is only slight expense for maintenance.

173. The rules call for a minimum size of 4,500 gals. and this size has been generally used until comparatively recently, when tanks of considerably larger size have come into quite common use. See Table 24, page 719, for tank size data.

174. Six thousand gallon tanks are common and 9,000-gal. tanks are frequently installed. In large properties groups or batteries of pressure tanks are installed, so that a heavy pressure water supply of 15,000 to 25,000 gals. of water is sometimes secured.

175. Considerable confusion has resulted from attempting to calculate the initial pressure required to produce 15 lbs. on the top line of sprinklers when pressure tank is empty, when the pressure tank is located below the top line of sprinklers. The rules say that the excess pressure (over 75 lbs.) shall be three times that due to the height of sprinklers above the tank. An example illustrates why.

176. Assume highest sprinklers to be 50 ft. above tank, then air pressure maintained in tank must be 75 lbs. plus three times the pressure due to 50-foot head, or 75, plus 3 times 23, equals 144.

177. Explanation—The tank is two-thirds full of water and air pressure is 144 lbs. Highest line of sprinklers is 50 feet above tank; which equals 23 lbs. pressure at tank due to head.

178. The pressure of air in tank will be inversely as the volume; i. e., if volume of air is increased three times, pressure will be decreased in same proportion.

179. The actual pressure in tank is 144 lbs. gauge pressure, plus 15 lbs. (approximately) atmospheric pressure, equals 159 lbs. In order to expel all water from the tank the volume of air will increase three-fold and pressure decrease to one-third of 159 lbs. (actual pressure) or 53 lbs. (actual pressure). Deduct 15 lbs. (atmospheric pressure) and there remain 38 lbs. gauge pressure at the tank.

180. This is sufficient to overcome the 23 lbs. pressure due to head and leave 15 lbs. final pressure (the amount required) at highest sprinklers.

181. Figure 169, page 722, gives the needed data at a glance.

182. Figure 170, page 723, shows gallons discharged or pumped into tanks of standard sizes equivalent to any differences in initial and final pressures. This information is particularly valuable for field test purposes.

183. Figure 57 shows standard discharge, fill, air, and gauge glass connections on pressure tanks.

NATIONAL BOARD RULES

(Edition of 1919)

184. The following extracts from the regulations of the National Board of Fire Underwriters for the installation of Pressure Tanks are reproduced as being of general interest.

81. Capacity.

Total capacity of tank must be specified by the inspection department having jurisdiction.

Sizes less than 4,500 or over 9,000 gals. are not recommended. In cases where pressure tanks are the primary supply to dry-pipe systems it is advisable to provide a larger tank capacity than would be required for an equivalent number of sprinklers on a wet-pipe system.

82. Location.

Tank not to be located below upper story of building.

83. Tank Service.

Tanks to be used only as a supply to automatic sprinkler systems and hand hose.

85. Test.

Tank must be tested at the shop and proved tight at a hydrostatic pressure of at least 50 per cent. in excess of the normal working pressure required. After erection, the tank, two-thirds full of water, must be tested at the working air pressure required. In this condition and with all valves closed, tank must not show loss of pressure in excess of ½ lb. in 24 hours.

89. Maintenance.

Tank must be painted inside and outside, with a good quality of lead paint, must be cleaned, scraped and repainted when necessary. Tank must have a hydrostatic pressure test similar to one noted in Section 85, once in two years.

90. Air Compressor.

A steam or electrically driven air compressor having sufficient capacity to increase the air pressure at an average rate of at least one pound in two minutes should be provided.

A properly designed safety valve must be installed at the air compressor, or in the pipe from it to tank, so that an excessive air pressure may not be pumped into tank.

91. Tank House.

Tank must be properly protected from frost, and if located above the roof must be enclosed in a house of substantial construction, easily accessible and of sufficient size to provide ample space on all sides. Must be arranged so that it can be properly lighted at all times.

There should be a space of at least 3 ft. at end where guages are located and a window should be provided opposite gauges.

Tank house must be constructed in accordance with the requirements of municipal or building authorities where they exist.

92. Supports for Tanks.

Tanks to rest on a cradle of cast-iron, concrete or other equally rigid material which will prevent possible sagging or vibration. Wood is not approved for this purpose. Supports must be proportioned so as to safely carry the load, using a factor of safety of at least four, and must be installed under the requirements of the municipal or building authorities where they exist. There should be at least one support for every section or course of the tank and the ends should not overhang more than 4 ft.

CONCRETE RESERVOIRS AND VALVE PITS

185. In the National Board Rules on Gravity and Pressure Tanks will be found detailed specifications for the construction of concrete reservoirs and valve pits. Reinforced concrete is used almost exclusively for such construction purposes today, being as a rule both cheaper and better than brick construction. For dimensions of reservoirs see Tables 22 and 25.

NATIONAL BOARD RULES

(Edition of 1919)

186. The following extracts from the regulations of the National Board of Fire Underwriters for the installation of Concrete Reservoirs and Valve Pits are reproduced as being of more general interest.

RESERVOIRS.

It is believed that concrete proportioned for maximum density, properly reinforced and carefully mixed and placed, is the best material that can be used for water-tight reservoirs. Either rectangular or circular form may be used. The circular form admits of a more economical arrangement of reinforcement and gives the greatest resistance against both external and internal pressure.

68. Sump.

A sump consisting of a recess at least three feet square and three feet deep to be located so as to come under manhole in roof. The surface of the floor to be carefully graded to produce a uniform pitch to the sump.

(*c*) If a reservoir is completely roofed over, a trap door at least 20 by 26 ins. to be provided in the roof so arranged as to be easily opened. Permanent ladder to be accessible from the opening.

70. Leakage.

(*a*) Leakage for the first 24 hours after filling shall not be more than 5 per cent. of the total reservoir capacity. If more than 5 per cent., water to be drawn off and porous concrete cut out and spaces filled with rich cement mortar.

(*b*) Reservoir must be substantially water-tight after having been filled with water 14 days.

VALVE PITS.

The rules for Materials, Mixtures, Forms, etc., given for large reservoirs, also apply to small reservoirs and valve pits.

72. Size.

The size should be ample so that there will be a space of at least 12 ins. around all valves.

73. Floor.

Concrete to be at least 4 ins. thick and reinforced with metal lathing or rods.

74. Walls.

Walls to be of concrete at least 4 ins. thick and reinforced in a similar manner to floor.

75. Roof.

(*a*) To be not less than 6 ins. thick and properly reinforced to carry load to which it is liable to be subjected.

(*b*) A standard manhole cover to be placed in the top of each pit. Six inches below the iron cover a second cover of 2-in. plank to be placed on a ledge formed in the concrete. Ledge to be at least 2 ins. wide. In regions where extremely cold weather occurs it is advisable to fill pit with a suitable insulating material, such as hay or straw.

77. Waterproofing.

If a waterproof pit is necessary, as in water-bearing ground, the entire outside surface of pit should be thoroughly waterproofed.

The following method is advised. Surface to be painted with hot tar or asphalt and then covered with at least two layers of tarred felt and hot tar or asphalt alternately. Felt to be lapped 18 ins.

CO-OPERATIVE WATER SUPPLIES

187. It is becoming more and more common for two adjoining or nearby properties to tie together their water supplies for mutual fire defense, both as regards individual plant fires and protection against exposing fire. If it is good for a plant to have two different sources of supply, it is obviously better to have cross-connections to other plants as well, provided only that the whole system is laid out with due regard to good water supply engineering. Possible methods of procedure are:

a—Two plants tie their underground systems together with a post indicator valve normally closed, but readily accessible at time of need.

b—All supplies normally on one header, the effect being the same as if all buildings were under one management.

c—Each plant pumps into a common emergency header through a check valve, and has a check connection with post indicator valve from the header to its own underground system, which connection it can use if desired. This is the plan used in the Atlantic City high pressure system, where hotel pumps feed a 20″ beach front main with 12″ laterals and many 4-way hydrants.

188. The July, 1920, Quarterly of the N. F. P. A., reports on a 27,000 gallon per minute co-operate system in Lawrence, Mass., presumably the largest in the country.

CHAPTER 27

OUTSIDE PRIVATE PROTECTION

1. This chapter deals with outside private protection features such as distributing mains, hydrants, hose, valves, and allied matters. It connects water supply, covered in preceding chapters, with interior apparatus and sprinklers, the treatment of which in succeeding chapters is limited to equipment inside of or attached to the building.

DISTRIBUTING MAINS.

2. Next in importance to a satisfactory water supply is an adequate distributing system. Such a system should be able:

a—To deliver the desired amount of water (generally the capacity of the water supply) at all important points without serious pipe friction. Keeping within a 25-lb. friction allowance is good practice, and a 50-lb. loss to outlying points may not be objectionable.

b—To permit concentrating all available water at important points with hose lines not over 250 ft. long. This usually calls for a fairly complete covering of the plant with the piping system.

SEPARATE FIRE AND DOMESTIC SYSTEM.

3. It is vitally important in almost every property, having outside distributing mains, that absolute separation be secured as far as fire and domestic piping is concerned. The principal reasons are:

a—Domestic piping frequently is not so heavy nor so well installed as fire piping, with subsequent breaks or blowouts when fire pressure is applied.

b—Domestic connections in buildings may be broken by fire and the system bled. Safely located control valves are seldom installed in combined systems. Also the amount of high pressure water available is, as a rule, quite limited.

c—Any normal flow through a domestic connection is increased by fire pressure, and all the water has to come from fire pumps. Shutting down or throttling down domestic outlets is feasible, but may not be done at time of actual fire.

d—Changes in domestic piping may interrupt fire service frequently in the course of a year.

4. While the foregoing general rule is fully justified by theory and by experience, there are conditions under which combined systems may be warranted, as, for example:

a—Where a new system is installed for a plant of good construction and not likely need of much water under fire pressure, as, for example, a modern steel mill. On such a system, domestic connections for several buildings can be fed from one connection controlled by post indicator valve, and thereby insure ability to shut off all domestic water at a few points.

b—Where domestic taps are very small, as for drinking water and plumbing purposes.

c—Where the main plant has separate systems, but outlying buildings require little domestic water, and to run separate piping would be expensive beyond the benefit gained.

5. There is no objection to having the same water supplies available in whole or in part for both fire and domestic systems, as long as the control of these supplies is absolutely safeguarded, as shown in illustration on page 326, and provided an underwriters' steam pump, for example, designed for occasional fire duty, is not run regularly for domestic purposes.

SIZE OF PIPE.

6. Many distributing systems are too small, partly because experience has shown the need of larger pipe sizes and partly because industrial plants commonly outgrow their piping systems. Formerly, 6-in. lines with 4-in. branches to hydrants were considered good practice. Now 8-in. or larger mains and 6-in. branches to individual hydrants is the rule.

7. In laying out protection for a plant, it is always important to consider the probable development of the property, to plan, in a general way at least, protection for the ultimate plant, and then to put in that part of the system of which there is immediate need.

8. Figure 58 shows a layout for a pretentious industrial plant in which all water supplies are available both for automatic sprinklers and for hydrant service. Figure 160, on page 680 (illustrating the application of standard plan notations), illustrates a simple system with gravity tank reserved for sprinklers and pump service available both for sprinklers and for hydrants. The future development idea is shown in each case. An 8-in. pipe laid, under ordinary conditions, costs only about 25 per cent. more than a 6-in. one, and the friction loss is one quarter as large. It must also be remembered that deposits on the inside of underground pipes reduce the area and increase friction. See table 1, on page 686 for friction losses in pipe.

9. Section M, of the rules covering Automatic Sprinkler Equipments, pertaining to underground piping, contain the following recommendations:

10. Hydrant Main—No 4-in. pipe shall be used.

11. For Pipes Extending to a Dead End:

a—Allow 200 ft. 6-in. pipe with one 3-way hydrant.

b—Allow 500 ft. 6-in. with one 2-way hydrant.

This might be extended in special cases.

c—Allow 1,000 ft. 8-in. pipe with one 3-way hydrant.

d—Allow 500 ft. 8-in. pipe with one 4-way hydrant or its equivalent in hose streams.

e—Allow 300 ft. 8-in. pipe to first hydrant, where there is a hydrant equivalent of 6 streams.

f—**Limit for Four Streams**—Whereas the above limitations for 8-in. pipe are low, it is deemed undesirable to have over 4 streams on a dead end, and the loop system would ordinarily be employed where it is intended to concentrate over 4 streams at one point.

g—**Limit for Three Streams**—Never allow more than three (3) streams on 6-in. branch pipe.

12. For Loop Systems:

a—**For Two 3-Way Hydrants**—With two 3-way hydrants, say 250 ft. apart, allow 250 ft. 6-in. pipe from each hydrant toward source (preferably use 8-in. pipe with 3-way hydrant systems).

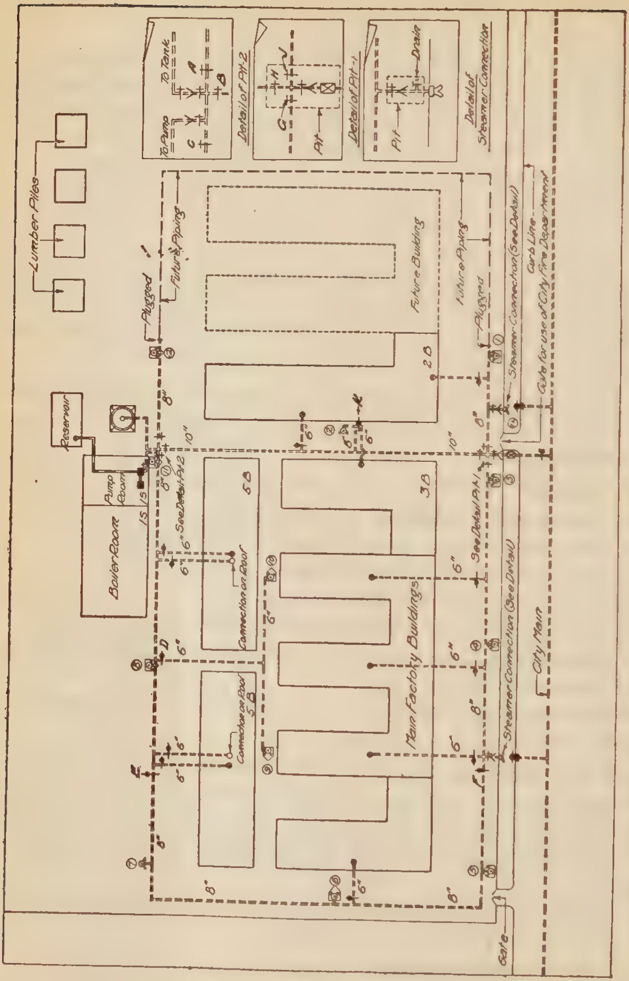


Fig. 58. Loop Fire Mains, Water Supplies, and Valve Control for Important Industrial Plant.

b—**For Two 2-Way Hydrants**—With two 2-way hydrants, say 250 ft. apart, allow 500 ft. 6-in. pipe from each hydrant toward source.

c—**For Three 2-Way Hydrants**—With three 2-way hydrants, 250 ft. apart, allow 250 ft. 6-in. pipe from end hydrants toward source.

d—**For Four 2-Way Hydrants**—To feed four 2-way hydrants, or their equivalent, use 8-in. main feed pipes and allow 500 ft. of 8-in. pipe each way from end hydrant to water supply, rest of pipe 6-in., if desired.

e—**For Five 2-Way Hydrants**—To feed five 2-way hydrants or their equivalent, use 8-in. main feed and allow 250 ft. from end hydrants to water supply.

f—**For Over Four Streams**—Where water supplies are such that over four streams can be obtained, loop pipe should never be less than 8-in.

g—**For Over Six Streams**—In laying out a loop system where it is intended to concentrate 4 to 6 streams at any one point, an 8-in. loop should be amply sufficient, even if it is as much as 1,000 ft. from supply to point of concentration.

h—**For Large Number of Streams**—Under conditions where a large number of streams can be concentrated at one point, it would sometimes be desirable to use 10-in. or 12-in. pipe.

COST OF LAYING PIPE.

13. Factors bearing on cost of laying pipe are cost of pipe and fittings at the foundry, freight, trenching, laying, occasionally piling, back filling, and testing. Conditions vary so much that it is impossible to present costs per foot generally applicable. However, under average conditions of trenching, the relative cost of laying pipe, with 6″ as a base, is approximately the following:

Size of Pipe	Relative Cost	Relative Friction Loss	Size of Pipe	Relative Cost	Relative Friction Loss
6	1.00	1.00	12	2.25	.035
8	1.40	.25	14	3.00	.016
10	1.85	.085	16	3.75	.008

PIPE SPECIFICATIONS.

14. Tar-coated, cast-iron pipe should be used for underground work. Steel, cement lined, or other special kinds of pipe are not approved. The 1908 standard specifications for cast-iron pipe and special castings of the American Water Works Association have been adopted by the National Fire Protection Association, and are recommended for all pipes and castings. Bell and spigot joints properly leaded have been almost universally used in the past with excellent results. Since 1916 the Laboratories have approved for general use a form of universal joint, for which a number of practical advantages are claimed, chiefly economy in trenching and in making up joints, that pipe can be laid on a curve and follow uneveness in the trench, and that no clamps or blocking are required, as each joint is bolted.

15. For private fire service, class C pipe (300 ft. equal to 130 lbs.) is recommended. The essential facts regarding such pipe are shown in the following tabulation:

CLASS C (130 Lb.) STANDARD PIPE

Nominal Inside, Diam. Inches.	Bell and Spigot Joint.			Universal Joint.		
	Thickness in Inches.	Weight Per Ft.	Weight Per 12 Ft., Length.	Thickness in Inches.	Weight Per Ft.	Weight Per 6 Ft., Length.
4	.48	23.0	280	.40	18.7	112.5
6	.51	35.8	430	.45	31.0	186
8	.56	52.1	625	.49	46.0	276
10	.62	70.8	850	.53	63.5	381
12	.68	91.7	1100	.57	80.5	483
14	.74	116.7	1400	.60	99.5	597
16	.80	143.8	1725	.65	123.0	738

16. The above weights are per length to lay 12 feet and 6 feet respectively including standard sockets and joints. For bell and spigot pipe sufficient plain tee jute packing must be used to insure stopping the lead, at least 1½ lbs. of pure pig lead is advisable per inch of diameter of pipe at each joint, and lead must be firmly driven and finished flush with the bell.

17. The pipe manufacturer should furnish evidence of Laboratories' approval or a certificate to the effect that the pipe delivered is in accordance with American Water Works Association specifications. Pipe also should be subject to local inspection, particularly for uniform thickness of wall. All pipe and fittings should be given a hammer test.

LAYING PIPE.

Section M of the Rules Covering Automatic Sprinkler Equipments contains the following rules for laying cast-iron mains:

18. Depth of Earth Cover—The depth of covering should be determined by the Inspection Department having jurisdiction, but will vary from 2½ ft. in the Southern States to 10 ft. in the northern part of Canada. Depth of covering should be measured from *top of pipe* to ground level. In a loose, gravelly soil, or in rock, the depth should be greater than in compact, clayey soil. A safe rule to follow is to bury the top of the pipe not less than one foot below the lowest frost line for the locality. As there is normally no circulation of water in private fire mains, they require a greater covering than the public mains.

Authors' Note: For protection against injury from surface loads or shocks, pipe may require more bury than is sufficient to protect against freezing.

Placing pipes over raceways or near embankment walls should be avoided as far aspossible, and special attention given to protection against frost where it is necessary to so locate them.

Where mains are laid in raceways or shallow streams, care should be taken that there will be a sufficient depth of running water between the pipe and the frost line during all seasons of frost, and a safer method is to bury the main under the bed of the waterway not less than one foot. Care should also be taken to keep the mains back from the banks a sufficient distance to avoid any danger of freezing through the side of the bank above the water line, and with low banks mains should be buried below the frost line where entering the water.

19. Care in Laying—Pipes should be clean inside when put in trenches, and open ends plugged when work is stopped, to prevent stones rolling inside.

Authors' Note: This is a vital matter. Many a fire system has failed or required expensive cleaning out because rocks, bricks, wood, old clothing, and other foreign matter got into mains while being laid.

20. Pipes should bear throughout their length, and not be supported by the bell ends only.

21. *Specials*—Specials should be used for making offsets and bends, and reducers for changing size of pipes, as thick lead joints or joints with lead mostly on one side are liable to leak.

22. *Back Filling*—Back filling should be well tamped under and around pipes to prevent settlement or lateral movement, and should contain no ashes, cinders, or other corrosive materials.

23. Rocks should not be rolled into trenches and allowed to drop on pipes.

24. All plugs at blanked openings and all bends in soft ground should either be strapped or secured by masses of concrete against the ends or sides of trenches to avoid any possibility of joints blowing apart.

Authors' Note: For methods of strapping piping see Fig. 59.

25. In trenches cut through rock, back filling should preferably be entirely of earth, but earth shall be used under and around pipe and for at least 2 ft. above same. If soil is of quicksand it may be necessary to support piping on piers. Under railroad tracks, pipe should be provided with special supports and reinforcement at joints. Underground, through buildings, flanged cast-iron pipe with metallic gaskets or other standard pipe should be used.

26. Mains should not be laid under piles of coal or other material liable to make the ground settle and cause leaks.

27. *Steep Inclines*—Down steep hills mains should be properly anchored. A general rule is to anchor the pipe at the bottom of the hill, at any turns, and otherwise on straight runs about every forty-eight feet. The anchoring should be done either to natural rock or by means of brick or concrete piers. The piers should be built around the pipe, or an iron rod not less than ¾-in. in diameter placed around the pipe and the ends anchored in the piers. Bell ends should be uphill.

28. *Blow-off*—Where feasible, blow-off should be provided at low point of underground main, and it is also advisable where an underground main crosses water.

29. *Clamps*—Clamp rods where used for strapping pipe should preferably run from the bell to the next bell or fitting, but may be run to clamps on pipe, provided clamps are of either malleable iron or steel and are not less than 2 inches wide and not less than ⅜-in. thick. The bolts holding the two pieces of clamp together should be not less than ⅝-in. round, of steel or wrought-iron, and the clamp rods should be not less than ¾-in. round steel or wrought-iron. Clamps, straps or rods should be protected against corrosion by painting with tar, asphaltum, or by other suitable means, See Fig. 59.

30. *Leading Joints*—Joints should be carefully leaded, and packing should be in the smallest quantity necessary to stop the lead. Rings should be shrunk on ends of short length of pipe to form beads. These are very essential in order to prevent yarn and lead from passing into pipe, and also to make joint hold. Socket joints should not be located in, or close to, foundations.

31. Large yard systems should have sectional controlling valves, and a valve should be provided on each bank where a main crosses water.

32. Testing—All piping when completed should be tested for not less than two hours at a pressure of not less than 150 lbs., and if the normal pressure exceeds 100 lbs., for not less than 50 lbs. in excess of that pressure.

33. Where feasible, test should be made with fire pumps running, and every hydrant should be opened and closed so as to test it, and at the same time produce some water hammer on the piping, as in the case of actual fire. The system should also be thoroughly flushed out by opening the various hydrants wide, thus, drawing large quantities of water and cleaning out small stones, sand, and other obstructions which will plug play pipes and sprinklers if allowed to remain until the time of fire

34. Branches to the inside sprinkler equipment should also be flushed out before connecting the sprinkler riser. If fire pumps are not available, underground piping may be tested out by means of a hand pump.

35. In any event, the system should be tested under water pressure to detect leaks which, even if small, when running continuously, cause large waste of water, and if possible pressure should be put on the pipes before the joints are covered, in order that any leaks may be readily located. Tests should be made by contractor in presence of inspector of the Inspection Department having jurisdiction.

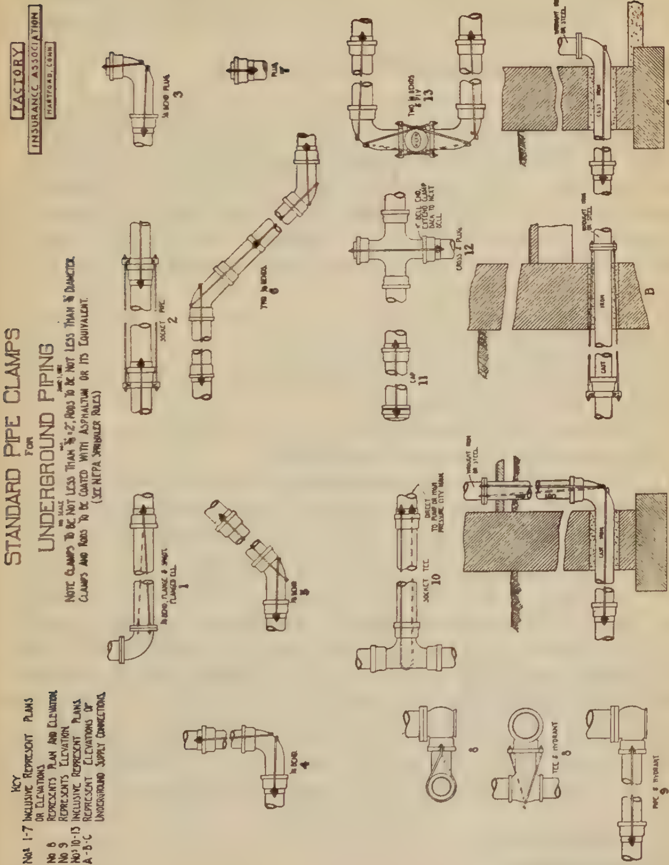

STANDARD PIPE CLAMPS
FOR
UNDERGROUND PIPING
NOTE CLAMPS TO BE NOT LESS THAN ⅝"×2", RODS TO BE NOT LESS THAN ⅝" DIAMETER.
CLAMPS AND RODS TO BE COATED WITH ASPHALTUM OR ITS EQUIVALENT.
(SEE N.F.P.A. SPRINKLER RULES)
FACTORY INSURANCE ASSOCIATION HARTFORD, CONN.
KEY
No's 1-7 INCLUSIVE REPRESENT PLANS OR ELEVATIONS
No 8 REPRESENTS PLAN AND ELEVATION
No 9 REPRESENTS ELEVATION
No's 10-13 INCLUSIVE REPRESENT PLANS
A-B-C REPRESENT ELEVATIONS OF UNDERGROUND SUPPLY CONNECTIONS
1
2
SOCKET PIPE
3
4
5
6
7
PLUG
8
TEE & HYDRANT
9
10
SOCKET TEE
11
CAP
12
CROSS & PLUG
13
A
B
C
WROUGHT IRON OR STEEL
CAST IRON

Fig. 59. Standard Pipe Clamps for Underground Piping (Courtesy Factory Insurance Association)

Authors' Note: One advantage of having sectional control valves in a fire system is the ability to test a portion of the system at a time. See Fig. 58, for method of valving a fire system so as to secure effective valve control for repair and test purposes.

INCRUSTATIONS AND DEPOSITS IN PIPE.

36. There are few situations where, in course of time, the cross section of pipes is not reduced or their surface roughened because of tuberculation, incrustation, or sedimentation. Startling conditions have been found in large cities where the water systems were under managements that understood the dangers. An excellent treatise of this subject appears in the January, 1918, Quarterly of the N. F. P. A. The author points out that incrustations may be due to:

a—Tubercular-corrosion or rust.

b—Chemical constituents of the water.

c—Growth of biological or living organisms.

Deposits may be due to:

a—Sediments such as mud, clay, leaves, or vegetable decay.

b—Foreign matter other than sediment.

37. The existence of serious trouble can generally be detected by careful friction tests. See Chapter 26 for methods of conducting such tests. Flushing out of the system will, of course, remove ordinary sediment. Operation of valves will sometimes show presence of sediment or corrosion. Local water conditions should be taken into account in establishing a regular procedure of flushing and testing. Pipe can be cleaned by the use of a scraper, technically termed "go devil," either pulled through the pipe by a cable or forced through by water pressure. One of the arguments for using tees and crosses liberally in an underground system, where ells or tees would do, is the ability to inspect and clean mains without breaking into the piping.

HYDRANTS

SPECIFICATION.

38. Experience in the field has developed difficulties in the opening and closing of hydrants, the working loose of interior mechanical parts, leakage (especially dangerous in freezing weather), excessive friction losses, failure to drain, loose nipples, and other defects. The National Standard Hydrant, covered by the N. F. P. A. specifications, is designed to obviate these difficulties. Its characteristic features are:

a—Liberal area of valve opening and barrel, and easy curves to reduce friction.

b—Heavy construction throughout.

c—Flanged bolt circle above ground level to permit turning outlets in desired direction.

d—Bosses for bolting on standard hose valves.

e—Large drips.

39. A number of makers can supply National Standard hydrants, and their purchase is urged.

40. Figure 60 shows two well-known hydrants in cross section. The one on the left is of the compression type, water pressure holding valve to the seat, and the other of the design closing against the pressure. For hose threads see page 410.

DIRECTION TO TURN.

41. If possible, hydrants should turn in the same direction as city ones, and those in the plant should always turn in same direction. A raised arrow (sometimes brass screwed to top of hydrant) can be used to show direction to turn, and such arrow should be prominent enough to be felt at night.

NUMBER.

42. A liberal number of hydrants makes for economy and efficiency. A hydrant costs only two to three times as much as a length of good hose. The depreciation on hydrants is far less than on hose. The friction in long hose lines is a serious matter; the friction in a hydrant almost nothing by contrast. Sufficient hydrants should be installed so that 150 ft. of hose from the two nearest hydrants will reach any fire in the central sections of a plant, and not over 250-ft. lines need be connected to nearest hydrants to concentrate the available water on important buildings. On important loop mains, hydrants are seldom located over 150 to 200 ft. apart.

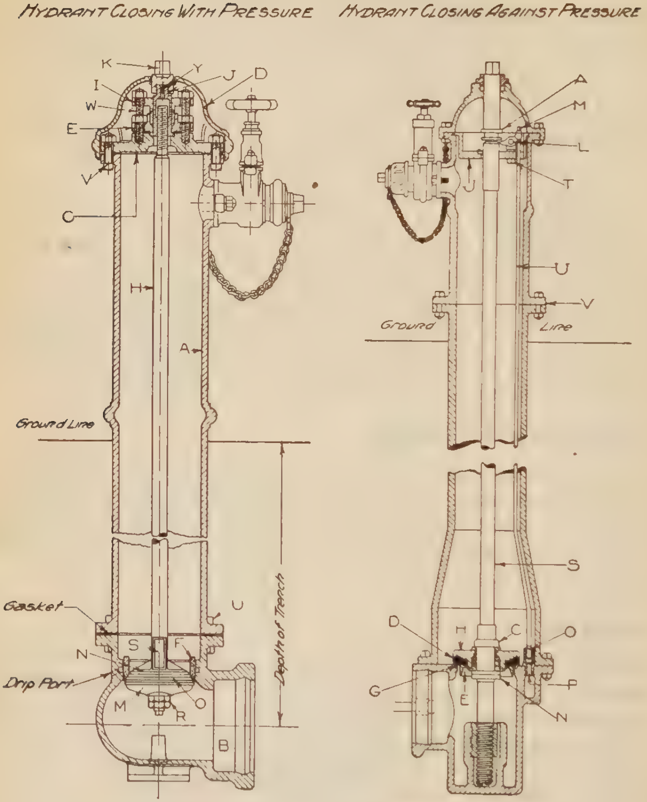


FIG. 60. MILL YARD HYDRANTS.
(Courtesy of The Kennedy Valve Manufacturing Co.) (Courtesy of Eddy Valve Co.)

LOCATION.

43. If located too close to buildings or lumber piles, it may not be possible to reach hydrants at time of fire, or they may have to be abandoned with possible crippling of the entire system. Hydrants should be not closer than 40 ft. to 50 ft. from buildings of ordinary height. If a building contains slight fire risk, as a concrete machine shop, hydrants can be placed close to walls if necessary. Hydrants should be located so as to keep them out of roadways, away from railroad tracks, and, if possible, out of line of future buildings.

SETTING.

44. Hydrants can advantageously be set on a block of stone or concrete. They should be securely strapped to underground piping, especially if they are on a branch or a dead end. A large block of stone or concrete placed behind the hydrant will minimize the tendency to blow off in event of water hammer. About a bushel of loose stone should be placed around the bottom of hydrant to facilitate drainage. In clay soils, special drain pipes from drips to nearby sewers are often advisable.

FREEZING.

45. Many hydrants in private fire systems have been found frozen especially where cold spells are protracted. Suggestions for detecting freezing include:

a—Sounding by striking hand over open outlet. Water or ice shortens the length of the "organ pipe" and raises the note.

b—Partial turning of hydrant stem. If frozen, steam will not turn.

c—Lowering weight on stout string into hydrant. It may strike ice, or come up with string wet, indicating level of water in barrel.

Frozen hydrants without digging up may be thawed by:

a—Use of steam hose.

b—Quicklime thrown into barrel and hot water added.

c—Cutting frost with alcohol.

d—Handful of calcium chloride which reacts with water and generates heat enough to melt ice. With methods (c) and (d) the presence of fire may cause explosion in hydrant barrel.

46. Where drainage is poor, or ground water stands at dangerous levels, it may be necessary to close up drips altogether and either pump out the hydrant barrels or force water out through the medium of special facilities provided for that purpose.

MAINTANANCE.

47. In addition to protection against freezing, there are various other important maintenance matters such as:

a—Keeping hydrant clear of obstructions.

b—Keeping it well painted, greased, and oiled. In very cold climates a valve stem packing of hemp and tallow has been found satisfactory.

c—Testing hydrant under pressure, with caps on and main gate open. An aquaphone will show if drip valve leaks, when it should be shut. An aquaphone is reported also to show if there are leaks in the mains near the hydrant where aquaphone is applied.

d—Flushing out hydrant thoroughly.

GATE VALVES.

TYPES AND PROPER USES.

Gate valves in distributing mains may be of three kinds:

a—Underground valves requiring key to operate.

b—Underground valves with indicator posts attached.

c—O S & Y (outside screw and yoke) valves in pits.

48. The first type of valve should not be used where quick action may be necessary at time of fire or in event of a break in a main. For repair shut-off purposes, at each hydrant or on one side of a check valve, it is not objectionable. For loop repair valves, where speed in locating valves and in operating them may be a factor, it should not be employed. The difficulties of finding valves, of getting up cover plates, and of locating a wrench that will fit and is long enough have all been impressed on the experienced inspector or plant manager. All underground valves should be the same hand and have the same size nut on valve stems. The valve locations should be clearly marked on nearby buildings.

49. O S & Y valves, if underground, must be in pits. Important junction points, as is shown in Fig. 58, often warrant the use of pits to cover several valves. O S & Y valves are commonly put in pits on one or on both sides of check valves or meters. They are universally used on inside piping, as they show the position of the gates at a glance. They are commonly strapped or otherwise sealed open. One good operating "wrinkle," where valves are in pits, is to slip a metal sleeve, with upper end closed, over the valve stem to keep off dirt.

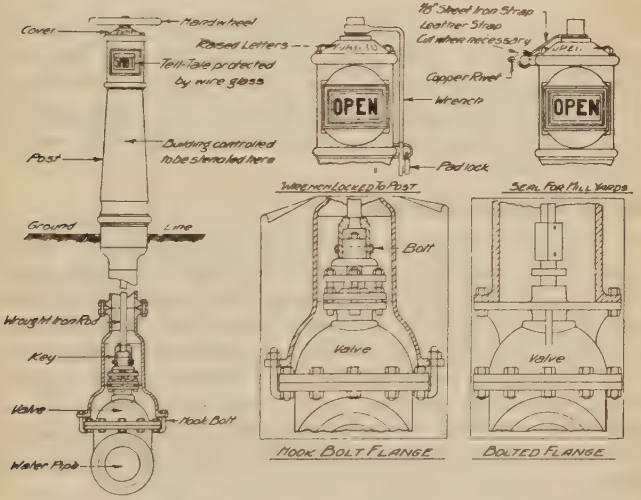


Fig. 61. Indicator Posts, showing Two Methods of Attachment

50. The indicator post attached to an underground gate valve is ideal, is required for sprinkler and other important controls, is generally used on fire systems, and occasionally found on domestic ones. In such cases, colors for posts should be different, as red for fire and green for domestic systems.

51. Figure 61 shows methods of securing posts to underground valves. The use of a special valve bonnet is preferable to the use of clamps.

52. Indicator posts can advantageously carry metal plate showing what they control. Painting building names or numbers on them is always advisable. The proper direction to turn should be shown. The raised arrow method is good. Posts often are locked in the open position to prevent tampering. Lock shackles should, however, be brittle so that locks can be removed quite readily if they are frozen and keys will not work. Posts should preferably have a wheel or wrench attached. Wired glass is recommended for target openings.

TESTS.

53. In order to make sure that underground valves are in working order, it is good policy to operate them at least once a year during non-freezing weather. More frequent operation is objectionable largely because it is likely to cause stuffing boxes to leak. Oiling or greasing valves annually is generally considered good practice.

POINTS WHERE NEEDED.

54. There has been considerable difference of opinion among fire protection engineers regarding the extent to which valves should be used in a system of underground mains. It has been stated, probably correctly, that more plants have been destroyed on account of a valve being shut than because of a system being out of commission owing to the lack of repair valves. Nevertheless, the modern tendency is to make fairly liberal use of system valves, and Fig. 58 shows about the maximum that would be advisable with such an important layout. Well established principles shown there are:

a—City supply check valve (and meter, if required) between gates so it can be repaired without affecting city or plant systems.

b—Pump check between gates, one to protect system against check valve repairs, and the other (not nearly so important) to enable pump hose connections to be used if check is out of commission. Also this valve is useful for testing pump and gives quick control in event of a break in fire main.

c—Tank check between gates, one to protect system and the other to avoid emptying tank if check needs repairs.

d—Pits Nos. 1 and 2, in addition to water supply valves, each contain three sectional valves, two to take care of present loop and one for short branches which will ultimately be part of the second loop. A loop valve belongs on each side of every valuable water supply so as to permit cutting off a part of the loop without cutting that water supply off altogether. Sometimes post indicators are attached to valves in pits, and posts are cemented into the concrete tops.

e—Indicator posts E and F are repair valves to cut loop (in connection with valves in pits) into four sections. Generally not over 6 hydrants or indicator posts should be located between loop repair valves. Note that individual hydrant repair valves are not needed with loop valves properly arranged. As shown, the layout has eight present and future loop valves, four less than individual hydrant valves would make necessary, giving control of piping and post indicators as well as of hydrants.

f—Some authorities prefer individual repair valves for every hydrant, and fewer loop repair valves.

g—Individual repair valves must always be provided where hydrants are connected to a water main of primary importance.

h—Hydrants Nos. 9 and 10, located where they might have to be abandoned owing to falling walls, are controlled by an indicator post at a safe point.

i—Indicator post K is on a branch fed by looping back across road. Both pipes are in same trench. Putting hydrant No. 2 on same branch makes for pipe economy.

j—Wherever approved valves can be secured, these alone should be purchased.

For valve data see also sprinkler rules, section F.

VALVE RECORD.

55. A plant having a fire system of any appreciable size seldom has more than one or two men who really understand the valve system. These men are likely to be pipe-fitter or plumber foremen. While their knowledge may be available to the fire brigade at time of fire, it is an element of weakness not to have a considerable number of men posted as to the location of all valves, especially sectional repair valves, and exactly what the various valves control. In event of a break in the underground system, or the abandonment of a broken connection or a flowing hydrant, it is essential that the waste of water be promptly shut off and that the minimum number of other hydrants or sprinkler connections be affected. It is also essential that the fire brigade promptly transfer its hose lines from hydrants shut off to the most advantageously located ones still in service. To handle such a situation correctly and rapidly at time of fire, especially at night and under snow conditions, requires accurate knowledge. The best results are secured in the following manner:

a—Securing an accurate map and making a study of the valve system, recording in tabular form the valve or valves necessary to cut off each hydrant and post indicator (and, of course, piping to or near them), and listing the hydrants and post indicators also affected.

b—Putting this data in note-book form for convenient study and reference.

c—Making officers of the fire brigade study and learn the conditions.

d—Holding drills in which it is assumed that breaks in piping have occurred.

e—Posting in fire brigade headquarters the facts regarding any interruptions of the system, and also preferably notifying the fire brigade officers of the facts.

56. The National Board regulations of 1921 for the Supervision and Care of Valves Controlling Water Supplies for Fire Protection cover:

a—Central station automatic supervisory service.

b—Local automatic valve notification systems.

c—Local non-automatic valve recording systems.

d—Valve sealing systems.

Details as to tags and seals will be found in the booklet as well as suggestions regarding a valve index board to give prominence to tags for valves under repair.

CHECK VALVES.

57. In Chapter 26, on Water Supply, page 324, emphasis is laid on using straight way check valves, on having each water supply checked against the other, and on having checks in pits where readily accessible for inspection and repairs. See also section on prevention of pollution, on page 325, and Sprinkler Rules, Section F. Where automatic water supplies, as city connection and gravity tank, exert about equal pressures, considerable difficulty is likely to be encountered in keeping checks tight. Tanks occasionally empty themselves into city mains under such conditions. Checks can be tested by raising pressure, where pump is provided, and sediment can be removed from seats by thoroughly flushing out of pipes. Checks should be placed horizontally.

HOSE.

TYPES.

58. Hose installed in connection with outside protection should be designed to permit of regular tests and drills. Consequently unlined-linen hose is not suitable. Cotton rubber-lined and, in certain cases, rubber hose are recommended. The National Standard Mill Yard Hose is especially designed for private plant protection. It is single-jacketed, cotton-rubber-lined, light, flexible, and amply strong for all ordinary requirements. In some plants where rough service is likely to damage fabric, double-jacketed hose, such as is ordinarily used by public fire departments, is advisable.

59. In certain forms of chemical plants, where cotton fabric is liable to be destroyed by fumes or liquids, rubber hose, made of wrapped duck and covered inside and outside with rubber, is the only available hose, except petrolatum or oil-sealed fume-tight boxes for linen hose are employed.

60. The National Standard Mill Yard Hose has an internal diameter of 2⅝ in. with 2½ in. couplings. No other diameter is recommended.

BRANDS.

61. A large amount of hose now in service is of little or no value, owing to the inferior quality or poor care. Good hose means good rubber and fabric and is therefore necessarily expensive. On the other hand, cheap hose is unreliable and costly in the end.

62. The life of cotton rubber-lined hose depends chiefly upon the lining. In good single-jacketed hose the lining represents approximately two thirds of the total manufacturing cost, and since it is almost impossible appreciably to cheapen the cotton fabric without seriously impairing the strength of the hose, it is apparent that inferior rubber linings must be used when hose is sold at a low price. Almost any rubber lining appears suitable as viewed through the coupling and any lining will stand pressure tests when new, since its function is not to add strength, but to keep water from the fabric and to provide a smooth water way. After some aging, however, particularly if not tested at regular intervals, defects begin to show. Cracking at bends, developing numerous pin-hole leaks, and tearing loose from fabric are common defects, and these sometimes occur within a year or two after the manufacture of the hose, when as a matter of fact good hose, with reasonable care, should last a decade.

63. In short, property owners and inspectors cannot tell good from bad rubber-lined hose when it is new, either by looking at it or putting it under pressure, therefore they should purchase hose bearing the label of approval of the Underwriters' Laboratories.

COUPLINGS.

64. It is vitally important that all hydrant and hose couplings in a plant are the same and completely inter-changeable. Frequent cases of inability to couple two lots of hose together and to couple hose to hydrants prove the necessity for testing out the entire equipment carefully. A standard plug and ring are convenient for checking up a large equipment, and a larger plant needs a tap and dies for repairs.

65. All private hose should have the same thread as the public department which would be called upon for aid, and, if possible, the hose equipment of industrial plants that could help each other should be inter-changeable. Frequently, it is not difficult or expensive to alter hydrant nipples and hose couplings, and, even if the cost is considerable, such a move is almost always highly desirable. See National Board booklet on Standardization of Threads for Fire Hose Couplings and Fittings. The standard 2½″ hose male thread is 3$\frac{1}{16}$″ outside diameter, and there are 7½ threads per inch. An astonishingly large percentage of non-standard threads are sufficiently near the standard that with a special set of tools it is possible to bring about interchangeability. Every possible influence should be brought to bear to further hose-thread standardization. If plant couplings are not uniform with public department and nearby plants, a supply of adapters should be kept on hand.

CARE OF HOSE.

66. Hose is perishable and requires the best of care. It should be kept in standard hose houses or similar cool, well ventilated buildings. It should never be kept in pump house, boiler house, or other warm places, as rubber will quickly deteriorate under such conditions. Rubber or rubber-lined hose should be tested preferably three to four times a year, either at times of drills or during special tests. Once a year it should be put under a static test of from 100 to 150 lbs., maintained at least five minutes, to show up existing defects in fabric, lining, and attachment of couplings. To insure hose being properly tested and inspected, it is good policy to number the lengths using for this purpose figures stamped upon the coupling.

67. After being used, hose should be thoroughly drained and dried. At first glance, this might not seem essential, but attention is called to the fact that any defect in the lining will enable water to reach the cotton fabric and decay is then likely to result. In winter time, any water which has been left in the hose is likely to freeze and consequently make it valueless in event of fire.

68. To drain and dry hose most successfully, it should be elevated in a tower or hung from any convenient point outside or inside of a building. It usually requires half a day to do so properly. An alternative arrangement is to use a slatted sloping drying rack, usually 52 ft. long and 2 ft. wide, placed against the sunny side of a building. The mere running of a hose over a man's shoulder will drive out most of the water, but it does not drain it properly, or dry the fabric that may have become wet.

69. Fire hose should under no conditions be used for domestic purposes. No matter how much care may be exercised, hose will suffer and may be out of serviceable condition at time of fire. It is good policy to retire old fire hose to domestic service, adding sufficient new hose to make up the loss, and especially to mark domestic hose with some prominent mark, as a red stripe painted the full length, so as to make it possible at a glance to distinguish fire from domestic hose.

HYDRANT HOUSES AND EQUIPMENT

70. Hose houses over yard hydrants enable hose to be kept connected and folded upon shelves ready for immediate use. Where there is no trained brigade, or during night fires, or at time of heavy snow, the advantages of hose houses are particularly great. To give an idea of the relative rapidity with which fire lines can be laid and water turned on, it can be stated that with a good hydrant and hose house equipment the first stream can usually be obtained in about 30 seconds, and two or three minutes are required where a cart has to be run up, hose coupled to hydrants, run out, nozzle attached, and water turned on.

71. Hose or other appliances kept inside of a building may be inaccessible at the time of fire. Heated buildings cause cotton rubber-lined and rubber hose to deteriorate more rapidly.

72. Generally speaking, hose houses should be erected over all hydrants, or at least over those near important buildings. The detailed data and illustrations on the following pages are selected from the rules of the National Board of Fire Underwriters, which should be closely followed if the best results are to be obtained. The principal features are protection against the weather and ventilation, the ventilation being secured through slatted floor and shelves and vent spaces under overhanging roof, so arranged that rain cannot drive into building.

73. Hose is generally attached to one of the hydrant outlets, leaving one or more available for additional lines, which can be laid from a hose cart, or from reserve hose in the house. Sometimes double hose equipments are connected to one hydrant. One shelf in a standard hose house will carry 150 ft. to 200 ft. of single-jacketed cotton rubber-lined hose folded forward and back. So placed it will ventilate and can be readily inspected.

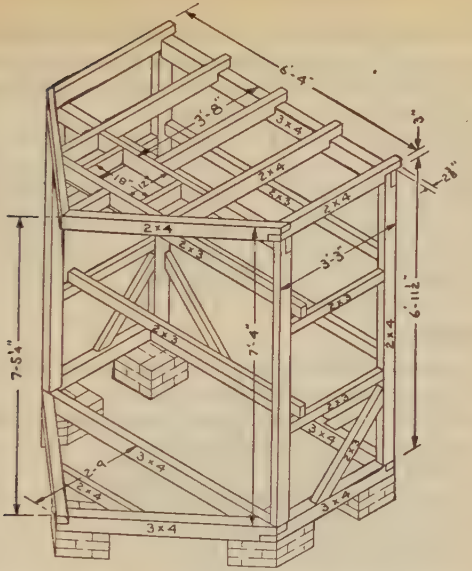


Fig. 62. Standard Mill Yard Hose House, 5 Sided

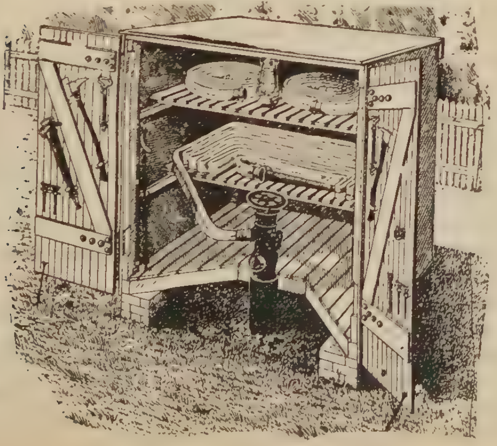


Fig. 63. Standard Mill Yard Hose House, 4 Sided

74. Where the conditions are such that it is necessary to lock hose houses, this can be accomplished by using a special lock with a brittle shackle, or by having a latch placed behind a glass plate which can be broken at time of fire.

75. The National Board Rules show five-sided and four-sided houses. The advantage of the former is somewhat greater accessibility of the hydrant. Generally, however, the four-sided house is easier and a little cheaper to build, and entirely satisfactory if made full size. Fig. 62 shows the framework of the five-sided house, and Fig. 63 the equipped four-sided one. From these views suitable buildings can be erected.

EQUIPMENT.

76. The usual equipment for a hydrant house consists of:

150–250 ft. of cotton rubber-lined hose.
2 Underwriters' play pipes, 30 ins. long, with swivel handles, and 1⅛-in. smooth-bore tips.
4 to 6 Tabor spanners.
2 fire axes, weighing about 6 lbs. each.
2 1¼-in. × 5-ft. crow bars.
2 canvas ladder straps.
1 extra hydrant wrench.
1 heavy mill lantern kept filled.
4 to 6 extra washers for hose couplings.
1 hand line of ⅝-in. Manila rope, long enough to reach roof of highest building to which department might climb.

Authors' Note: Operating "wrinkles" in connection with hose house equipment include:

a—Soaking axe helves in hot linseed oil to avoid shrinking of the wood.
b—Where there is more than one size of hydrant or indicator post nut, using a flat bar hydrant wrench with holes to fit all nuts.
c—Using lanterns with well protected glass fonts so as to permit telling at a glance if fonts are full of oil.
d—Many experienced plant fire brigade officers insist on using shut-off nozzles as do virtually all public departments. One very important advantage lies in ability to shut off water when hose tries to get away.

HOSE CARTS.

77. Hose carts are useful where there are no hydrant houses with hose normally coupled up, where supply is needed to back up hydrant houses, and where there are outlying sections to be reached. A private brigade cart, drawn by man power, should have a capacity not to exceed 500 ft. of 2½-in. cotton rubber-lined hose. The cart should be entirely of metal, and should carry a box in which hydrant wrenches, spanners, extra gaskets, etc., can be carried. One or two Underwriters' play pipes should be supported by clips or straps. Reel carts are used almost universally. See Fig. 64.

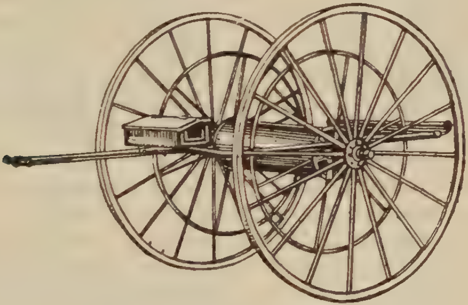


Fig. 64. Mill Yard Hose Cart
(Courtesy of Wirt and Knox Mfg. Co.)

78. Carts should preferably be stored in an outside building constructed along the lines of a standard, ventilated hose house, and provided with a sloping approach. This can ordinarily be in position or it can be swung up into the building before the doors are closed. Electric lights outside or inside such a cart house are valuable. An alternative is to use a red lantern.

MONITOR NOZZLES.

79. Monitor nozzles are generally placed on roofs of buildings to guard against exposure, but are also located on towers or trestles to protect railway car yards, pulp wood piles, and lumber yards, and occasionally on the ground where they are used in lieu of hydrants. Their use in tower form is steadily increasing where they are particularly suitable. The January, 1914, Quarterly of the N. F. P. A. contains a valuable article on Monitor Nozzle Protection of Lumber Yards. See Fig. 65 for illustration of tower and platform monitors, and for method of controlling roof monitors with valve and drain in heated portion of building. The following comments point out advantages and disadvantages of this form of protection:

a—Monitor nozzles can be used to wet down exposing burning buildings, burning equipment such as cars or lumber, and the exposed structures on which or near which they may be located.

b—Such nozzles require but one man to put them into service, and they can be left in operation, discharging in one definite direction, without attendants.

c—Nozzles can be put into service more quickly than hose streams, even where hose lines are already coupled to hydrants.

d—Monitor nozzles give a more effective stream for the same sized orifice on account of larger supply pipe, but require a correspondingly greater volume of water.

e—The fixed position of such nozzles is a distinct disadvantage.

f—Nozzles have a limited range, even under high pressures. See table on page 694. Distances given in table, while conservative, do not take into account an adverse wind.

g—Ordinarily, water from a monitor nozzle cannot reach fire within a building until the fire has broken through the roof.

h—A system of any size requires an exceedingly large water supply.

i—The cost of monitor nozzle protection is much greater than for a hydrant equipment if equal covering of a given area is to be secured.

PRIVATE BRIGADE

80. The necessity of having trained men to handle fire apparatus seems self evident, and yet many plants with private fire protection systems entirely neglect this important feature. Pumps, hose, hydrants, and other equipment need expert treat-

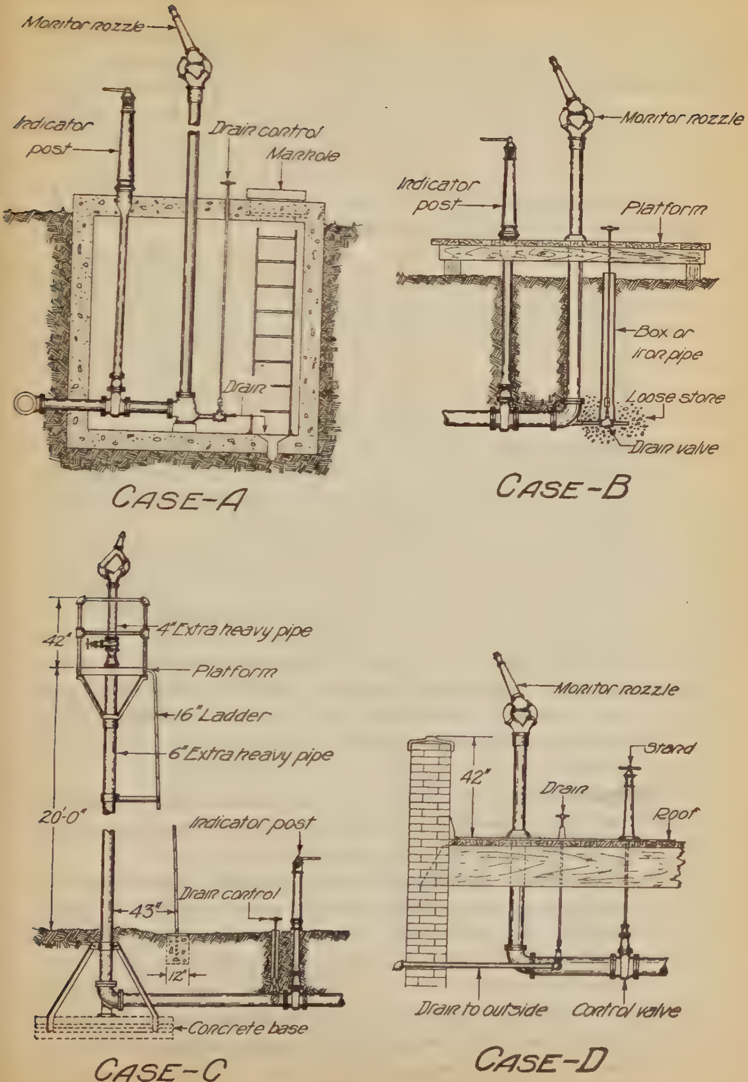


FIG. 65. MONITOR NOZZLES
(Courtesy Canadian Fire Underwriters' Assn. and Factory Insurance Assn.)

ment to bring out their full efficiency, and this cannot be obtained without a thoroughly drilled private fire department.

81. The 1923 Proceedings of the N. F. P. A. contain an excellent treatise on the Organization, Drilling, and Equipment of Private Fire Brigades. It lays down as fundamental: (a) rigid discipline, (b) provision and maintenance of necessary apparatus, (c) sufficient training under discipline and with apparatus. As to organization, the principal suggestions are:

a—**Chief.** For large plants a full-time man with fire department experience. For smaller plants a similar man, if possible, with a definite portion of his time available for inspection and drill purposes. Chief to have absolute charge of fire fighting (until the arrival of the public fire department, if any), and to reside close to the property.

b—**Assistant Chief.** A man with as nearly similar qualifications as possible. For large plants, there may be two or three assistant chiefs, one of whom is on duty during the entire twenty-four hours.

c—**Captains.** Preferably selected from among heads of departments, such as foremen, with fire fighting experience, if possible, and ability to command men. Captains should rank as first, second, third, etc., so as to establish seniority in absence of higher officers.

d—**Companies.** Generally ten men, allowing for two hose lines with at least four men per line. Maintenance men who know the plant are valuable for fire brigade members.

e—**Badges.** These should be provided for all members, partly to insure admission to plant when fire occurs at night or when they are off duty.

f—**Remuneration.** Membership in brigade should confer distinction and carry with it some privileges sufficiently attractive to make membership desirable. Payments of stated sums of money for service at fire drills and at fires, such as 50c. per drill or 50c. per hour are common, and sometimes a small salary as $25 per year is paid to brigade members. Occasionally a club room is provided. Failure to report for practice should involve a fine unless absence is unavoidable.

82. The maximum organization likely to be needed in a plant would require men available and trained to handle:

1—Notifying of public and other fire departments.
2—Fire pump or other water supply.
3—Outside hose streams.
4—Valve operation on fire and domestic systems.
5—Ladders.
6—Chemical engines.
7—Standpipes in buildings or on roofs and monitor nozzles.
8—Hand extinguishing apparatus such as extinguishers and pails.
9—Salvage.
10—Policing of fire grounds.
11—Rescuing of persons from buildings.

83. Experience with private plant brigades has indicated that, although most have rendered valuable services whenever an emergency has arisen, the organizations as a rule leave much to be desired when compared to the high standard of efficiency which brigades can reach. Deficiencies, which will suggest their own remedies, include:

a—Fire ground overrun with people, who interfere with fire fighting, and volunteers, not trained and not needed, taking a hand in work that is outside their province.
b—Men not sticking to their previously assigned duty, as staying at hydrants and turning on water only on word of man in charge of company or squad.
c—Brigade not drilled to do specific things, as company to use definite hydrants and previously arranged amount of hose for fire in a given building or section.
d—Too many lines of hose in service. A specific case was volunteers getting out eleven lines from system fed by one thousand gallon pump, and these being absolutely useless. When streams were reduced to two, fire was promptly extinguished.
e—Night brigade, such in name only. No drills held at end of day to take advantage of light.

f—No fire-fighting organization available between 6 and 7 A.M. and between 5 and 6 P.M., the interim period between day and night shifts.

g—Yard illumination at night not sufficient to enable prompt and safe work by private or public departments.

h—Men called on to fight long fires in winter and without adequate rubber coats, boots, hats, and warm mittens.

i—Men taking undue risks on ladders and roofs.

j—Men not posted as to methods of entering smoke-filled buildings, the dangers of smoke explosions, and the hazards of materials in buildings.

84. The value of a well-trained private fire-fighting organization, especially in large properties, is very great. It must not be forgotten that the public fire department may be engaged elsewhere when fire breaks out, and that in event of conflagration, the private fire brigade is generally the only force available for protection of property. The management should provide adequate equipment, pay necessary compensation, and take a live interest in the affairs of the brigade. Where there are two or more plants under one management, annual inter-plant contests do much to stimulate interest.

85. The N. F. P. A. report, referred to above, lists the equipment desirable for fire brigade use in a large plant, quite in addition to hydrant protection and regular interior equipment. The list is reproduced herewith, but it must be understood that exact quantities will vary greatly with different situations. It is interesting, almost startling, to observe the great variety of equipment required. Many of the items listed are discussed in detail in other portions of this book. See index when details are desired.

A—FIRE STATION EQUIPMENT

1. Isolated fire-resistive building in center of works.
2. Framed plan of water mains with all section control, sprinkler valves, hydrants and fire alarm boxes shown, and numbered.
3. Framed plan of watchman's route and stations.
4. List of Fire Brigade membership with addresses and tele-

phone numbers of Chief and other officers, Works Manager, local fire department, and Doctor.

5. Drill attendance book.
6. Hose and Chemical Extinguisher record book.
7. Inspection forms, and files for copies.
8. Red tag valve control board and supply of red tags.
9. Desk with drawers and chair, cuspidor.
10. Set of National Board of Fire Underwriters pamphlets applicable to local plant, Field Practice, and Standard Handbooks on Fire Protection.
11. Notice Board.
12. Couch.
13. One First-aid kit. Artificial respiration chart.

B—APPARATUS

1. 6 fire buckets.
2. 6 carbon tetrachloride extinguishers.
3. 3 2½ gal. soda acid extinguishers.
4. 3 2½ gal. foam type extinguishers.
5. 24 firemen's helmets, 24 pairs woolen mitts.
6. 24 pairs firemen's rubber boots (half hip).
7. 24 pairs firemen's rubber coats, belts, and spanners.
8. 12 kerosene lanterns trimmed, supply of safety matches.
9. 1 hose reel, 400 ft. spare hose.
10. Reel equipment: axe, steel bar, 1 nozzle, 4 wrenches, 6 hose straps, spare washers, and hydrant cut-out valve.
11. 50 ft. ½-in. rope.
12. 1 20 gal. or 40 gal. chemical engine.
13. 2 dozen hose straps.
14. 6 axes.
15. 1 cross-cut saw (2 handed).
16. 1 rip saw.
17. 4 spare 1⅛-in. play pipes, 2 flexible play pipes, with shut-off nozzle.
18. 100 ft. ½-in. Manila rope.
19. 200 ft ½-in. Manila rope and hook.
20. 3 electric lanterns.
21. 2 strong steel crow bars.

22. 1 ladder, at least 24 ft., or of sufficient length for the work required.
23. 6 salvage tarpaulins.
24. 1 deluge set, 3-way Siamese, nozzles 1½ to 2 in.
25. 4 double female hose couplings.
26. 6 hydrant cut-out valves.
27. 4 dozen hose coupling washers.
28. 1 door opener.
29. 2 smoke helmets.

C—SPARE EQUIPMENT AND STORES

1. 12 spare lantern globes.
2. 3 shovels.
3. 2 pitchforks.
4. 1 wheelbarrow.
5. 2 oil cans.
6. 1 1-gal. safety can for alcohol for thawing out frozen valves and hydrants. One can for kerosene.
7. 1 hand pump for excavations.
8. 2 kerosene oil heaters for emergencies.
9. 1 work bench, vise, sundry small tools, spanners, hammer, etc.
10. 2 dozen fusible links for fire doors.
11. 100-165 degree sprinkler heads.
12. 50-212 degree sprinkler heads. (Only required if 212° heads are used.)
13. 25-286 degree sprinkler heads. (Only required if 286° heads are used.)
14. 25-360 degree sprinkler heads. (Only required if 360° heads are used.)
15. 25 ordinary heads corroproofed. (Only required if corroproofed heads are used.)
16. 6 in., 8 in., 10 in. and 12 in. soft wood taper plugs, and wedges for water mains. Keep well oiled.
17. Hemp for pipe joints.
18. 100 lb. lead for pipe joints.
19. 1 hose coupling expander.
20. 2 dozen expander rings 2½-in., or local standard.
21. 150 ft. spare 1½-in. unlined linen hose (if used).

22. 1 dozen clips for unlined linen hose (if used).
23. 4 spare 1½-in. x ⅜-in. brass hand hose nozzles.
24. 400 lb. coarse salt.
25. 1,000 lb. calcium chloride for anti-freezing solutions.
26. 300 lb. bicarbonate of soda.
27. 4 gals. sulphuric acid.
28. 5 gals. special carbon tetrachloride fluid for 1 quart extinguishers.
29. 1 dozen spare acid bottles and stopples for extinguishers.
30. 1 dozen spare hose and nozzles for extinguishers, also cap washers.
31. 1 spare hydrant valve and spindle complete.
32. Spare rubber seats for dry-pipe valves if required.
33. 40-ft. extension ladder for sprinkler replacements.
34. 1 barrel of sawdust (preferably hardwood sawdust) and sieve.
35. 1 strainer and funnel for filling chemical extinguishers.
36. 1 small funnel for filling carbon tetrachloride extinguishers.
37. 1 pair of scales, 25-lb. capacity.
38. 1 pint measure.
39. 1 quart measure.
40. 3 dozen charges for Foam Type Extinguishers.
41. 1 set sprinkler fittings complete for 6-in. section.
42. 3 spare lengths 6-in., 8-in., 10-in., and 12-in. C. I. Pipe for water mains.
43. Spare lengths ¾-in., 1-in., 1¼-in., 1½-in. W. I. Pipe.
44. Spare parts for small dry-valve fittings.
45. Pressure gauge.
46. 1 tap and die for standard hose coupling threads.

VOLUNTEER FIRE DEPARTMENTS.

86. Volunteer, or Paid-On-Call, fire departments exist in far more communities than full-paid departments. Volunteer departments have no place in cities of any size, and, even in smaller cities, it is desirable to have at least a few full-time professional firemen as a nucleus for the department. Chapter 25, on Public Fire Departments, while written principally with larger cities in mind, contains much applicable to volunteer departments, and the preceding section on Private Fire Brigades considerable in addition. The Tennessee Inspection Bureau of Nashville, Tenn., has issued a suggested ordinance for Paid-on-Call Fire Departments. A number of N. F. P. A. articles also bear on this important subject.

FIRE LADDERS.

87. Almost every plant needs one or more fire ladders to enable the brigade to reach windows, roofs, and other high points. Generally, it is true that efforts to extinguish fire and protect exposed buildings will require more along these lines than would be expected. Good practice calls for one or more permanent ladders to the roof of every important building, where roof slope is not so great as to be dangerous, and one or more portable ladders of proper length (generally not over 40 ft. because too heavy to handle), for use wherever needed.

88. Permanent ladders should preferably be of metal, because of danger of wooden ladders rotting and failing at time of fire. They should extend at least 3 ft. above roofs or parapets. Good specifications are rails ½-in. × 2-in. bar iron, and 16 to 18 in. apart; rungs ⅞-in. round riveted to rails, and spaced 12-in. centers; ladder firmly supported and at least 8 in. from any portion of building which it passes. Permanent ladders are often placed opposite hydrants.

89. Portable ladders should be of the regular fire department type and long enough to reach highest points to which firemen might want to climb. Ladders should be protected against the weather and reserved for fire duty.

PLAN OF FIRE SYSTEM

90. An accurate plan of the entire fire system, showing underground piping, gate and check valves, hydrants, and post indicators controlling sprinklers is of great value, especially if an emergency arises requiring quick closing of valves which control the section in trouble, and not crippling the balance of system any more than can be avoided. Such a plan includes also building outlines and names as well. A 30 ft. scale is practical. Plans should be posted under glass in office, power house, fire brigade headquarters, and gate house, and it is often good practice to mount prints on linen, roll them up in an oilcloth cover, and keep them in hose house for use at time of fire. Plans are occasionally given to the public fire department for its information. Naturally plans must be kept up-to-date. The time to map new work is while it is being put in. The generally excellent plans of Underwriters' inspection departments either will answer this purpose or make a foundation for a plan drawn at the property. See Fig. 58, page 394, and Fig. 160, page 680.

PLANT ILLUMINATION.

91. It is true that it takes good artificial illumination to fight a night fire effectively and safely. In addition it is essential that roads be clear, housekeeping good, and the possibility of rapid work at night anticipated as far as possible. Yard lighting should be on separate circuits so that fires in buildings may not cripple the illumination at the critical time. Yard lights should be located with special reference to hose houses, hydrants, main roads, and permanent roof ladders.

FOAMITE.

92. The extinguishment of fires in oils and other volatile liquids in large storage tanks cannot effectively be accomplished with water or with steam. This has long been recognized by the oil refiners and producers.

93. About fifteen years ago, the foam method of fire extinguishment first came into use as an effective means of reducing the very considerable annual fire loss in oil properties, due principally to fires caused by lightning. This method of fire extinguishment involves the generation and application to the burning oil surface of a foam consisting of a mass of tiny bubbles inflated with carbon-dioxide gas which floats on the oil surface and smothers the fire. The efficiency of this method is now generally acknowledged, it is widely used, and the system as designed by the Foamite-Childs Corporation is approved by Underwriters' Laboratories.

94. In the early development in the art of foam fire protection many formulae were used for the chemical solutions, various materials were used as foam-making agents, and several methods employed for mixing solutions and applying the resulting foam to the burning oil surface. These were improved from time to time:

First: To secure greater efficiency from the solutions.

Second: To insure that the foam would reach the oil surface and without submerging.

Third: To make full storage capacity of the oil tank available.

Fourth: To insure that the parts of the system attached to the oil tank would not be damaged by the explosion which usually accompanies an oil tank fire.

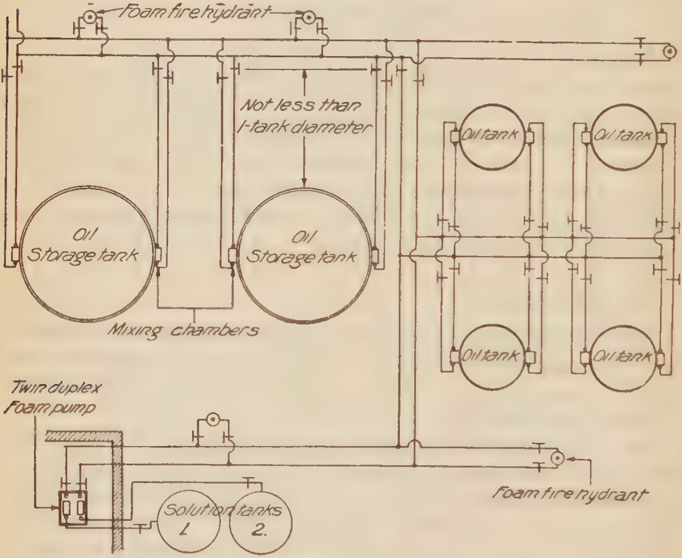


FIG. 66. MANUALLY CONTROLLED FOAM SYSTEM FOR EXTINGUISHING OIL FIRES

(Courtesy of Foamite-Childs Corporation)

95. Automatic systems were among the early ones employed in connection with oil storage tanks, but these have been abandoned as being unnecessary and unduly complicated.

96. Modern systems for the protection of oil storage tanks usually employ a steam driven twin duplex pump, by means of which the two chemical solutions are pumped from solution storage tanks through separate main solution headers running near all of the oil tanks which are protected. From these main headers, branches are lead to each oil tank where they are terminated in a mixing chamber. In case of fire, the valves in the branch lines leading to the mixing chamber attached to the tank on fire are opened and the pump is started, the two solutions being pumped through the main headers and the branch lines into the mixing chamber where they mix and form foam which is discharged enmasse down the inside of the tank on to the burning oil surface. There it floats and spreads out until the entire surface of the oil is covered and the fire is smothered. See Fig. 66.

97. To foam solution distributing pipes it is customary to attach special hydrants so that foam can also be discharged through hose lines.

98. The chemical solutions used in the FOAMITE system consist of:

" A "—Aluminum sulphate mixed with water, and
" B "—Bicarbonate of soda and Firefoam (employing licorice root) mixed with water.

99. The FOAMITE system has also been adapted to the protection of processing tanks used in manufacturing establishments. Such systems are usually automatic in operation. It has also been adapted to the protection of boiler rooms and pump rooms of oil-burning passenger and cargo ships.

100. See N. F. P. A. rules for Foam Fire Extinguishing Systems and for Marine Fire Hazards. See also page 451 for data re foam hand extinguishing apparatus.

SEALITE.

101. In 1922, the Standard Oil Company of New Jersey announced the commercial production of " Sealite," designed to reduce evaporation of oil from storage tanks and also the risk of fire. Crude oil and gasolene storage tanks need such protection most. It is claimed that experiments over a period of two years have proved the merit of the method.

102. " Sealite No. 553," is a mixture of glucose, cornstarch, glycerine, calcium chloride, and glue, beaten up to entrain air bubbles. It is a highly viscous fluid, weighing approximately 4.75 lbs. per gallon, which flows readily except at low temperatures. It loses its ability to flow at 25 degrees F. It has been held at 10 degree

F. and also at 180 degrees F. without change in properties. Some of its constituents are of a drying character and some hygroscopic; hence there is supposed to be no loss or gain of water upon exposure to air. It is soluble in water and insoluble in any petroleum oil. It is generally applied in a layer one inch thick, and, in standard size storage tanks, the cost is from 3 to 5c per barrel of oil protected.

103. From an evaporation standpoint, "Sealite" acts in two ways: first, it keeps the air from the surface of the oil, and, secondly, it protects it against the rays of the sun. It is reported to return in reduced evaporation 500% to 1,000% per year on the cost of protection.

104. From a fire protection standpoint, "Sealite" also acts two ways: first, the virtual elimination of evaporation makes ignition of oil vapor relatively difficult, and, secondly, the blanket acts very much as does "Foamite," in preventing the burning of the surface of the liquid.

105. The cautions offered by the manufacturer are primarily:

a—Solution is not recommended for working tanks, as the movement up and down causes the mixture to lose its entrained air, and the heavy ingredients drop to the bottom

b—Solutions are readily soluble in water, hence tight roofs are necessary, and steam cannot be used in a tank so protected.

FIGHTING OIL FIRES.

106. The difficulties of extinguishing an oil fire of size are generally great; sometimes, even in properties supposedly capable of coping with any situation, the loss is total and exposure losses also result. Obviously fire prevention assumes unusual importance in refineries, oil distributing stations, and similar properties. See pages 55 and 90. Similarly, retarding the spread of fire, by separation of tanks and buildings, and by dikes and walls is usually of vital importance, where a break in a tank may turn loose thousands of gallons of oil on fire over the entire surface. The preceding sections regarding "Foamite" and "Sealite" cover the best extinguishing methods yet devised, and "Sealite" also has merit as a preventive. In addition there are a number of points worthy of recording:

a—If oil has escaped from a tank and spread over a large area, no system of extinguishing can be relied on to be effective. For moderate areas, foam applied by hose lines may be adequate.

b—If a tank is threatened by fire, either exposure or lightning, filling the upper portions either with steam or with foam is a good precaution.

c—Facilities, through adequate large mains and ample pump capacity, for transferring oil from tanks on fire or threatened, are valuable in reducing amount of oil involved in a fire.

d—Floating booms, consisting of timbers connected by short lengths of chain, can be used to protect piers, ships, and other property in or adjacent to water on to which burning oil has spread.

e—One refinery uses an emergency foam tower on wheels to feed foam over the edge of a tank on fire. Supply to this tower is through hose lines.

f—Another excellent refinery fire prevention idea is the installation in the pump house, and elsewhere if desired, of a diagram showing each tank and its steam, water, and foam connections and control valves. A fight against a fire can be better planned with such a diagram.

g—Portable incombustible fire shields, slotted for a play pipe, are commonly used to enable fire fighters to approach closer to hot fires.

h—Asbestos clothing is feasible under such conditions, and has had some field use.

i—Shovel squads play an important part in restricting the spread of burning oils.

CHAPTER 28

INTERIOR FIRE EXTINGUISHING APPARATUS

(Exclusive of Automatic Sprinklers)

1. Practically all fires are small at the beginning. Many are discovered in their incipiency. For the lack of a convenient pail of water untold millions of dollars worth of property and many lives have been sacrificed. Interior fire extinguishing apparatus is needed primarily to take care of incipient fires, and for this reason the liberal use of suitable equipment is urged. Standpipes, whether fed by water or chemicals, if they have hose small enough for convenient handling, and if there are a sufficient number of connections, can to a large extent take the place of portable equipment. Large standpipe systems, employing 2½-in. hose, have far more value to a trained department than to the ordinary employees, and it is generally advisable to rely on outside private or public streams to handle fires that have gotten beyond the control of small apparatus.

2. On the opposite page appears a tabulation of available equipment, much of which is of course suitable for use outside as well as inside of buildings. See in this connection National Board Rules of 1922, covering First Aid Fire Appliances. Regarding this tabulation the following explanations are offered:

a—Capacities are the usual ones; some other sizes are also approved by Underwriters' Laboratories. Stationary Foam systems can be furnished in any desired capacity.

b—Steam jets require special designs to meet each situation.

c—Woolen blankets are excellent to extinguish fire in clothing, and asbestos ones to cover containers of inflammable liquids.

d—Discharge distance represent best average practice. When extinguishers depending on chemical reaction are cold, streams generally are much shorter.

FIRST AID FIRE APPLIANCES

and Underwriters' Laboratories' Classification

Col. 1.	Col. 2.	Col. 3.	Col. 4.	Col. 5.	Col. 6.	Col. 7.
Item No.	Kind of Equipment.	Capacity in Gals.	Method of Operation.	Discharge Distance in Feet.	Prot. Vs. Freezing Required.	Und. Lab's.' Classif.
	WATER:					
1	Pails	3	Manual	5–10	Yes	A–5
2	Pails in Tanks (5 pails)	22	Manual	5–10	"	A–1
3	Casks and Pails (3)	50	Manual	5–10	"	A–1
4	Hand Pumps	2½	Hand Gen. Press.	30–40	"	A–2
5	Hand Pumps	5	Hand Gen. Press.	30–40	"	A–1
6	Hand Hose 1½" to 2½"		Various	Various	"	A
	SODA-ACID:					
7	Hand Extinguisher	1½	Int. Gen. Press.	30–40	"	A–2
8	Hand Extinguisher	2½	Int. Gen. Press.	30–40	"	A–1
9	Wheeled Extinguisher	17	Int. Gen. Press.	50	"	A
10	Wheeled Extinguisher	33	Int. Gen. Press.	50	"	A
11	Stationary Extinguisher	100 up	Int. Gen. Press.	50	"	A
	FOAM:					
12	Pails	3	Manual	5–10	"	A–5; B–5
13	Automatic Foam Can	3	Int. Gen. Press.	1– 5	"	A B
14	Hand Extinguishers	2½	Int. Gen. Press.	30–40	"	A–1; B–1
15	Wheeled Extinguishers	33	Int. Gen. Press.	50	"	A B
16	Stationary Extinguishers	Desired	Int. Gen. Press.	50	"	A B
	NON-FREEZING:					
17	Carbon Tetrachloride	1 qt.	Hand Gen. Press.	10–20	No	B–2; C–2
18	Carbon Tetrachloride	1½ qts.	Hand Gen. Press.	10–20	"	B–2; C–2
19	Calcium Chloride Extinguisher	2½ gals.	Int. Gen. Press.	30–40	"	A–1
	MISCELLANEOUS:					
20	Sand Pails	3 "	Manual	1– 5	"	B–5; C–5
21	Sawdust and Soda	8 bu.	Manual	5–10	"	B–1
22	Steam Jets		Special			
23	Carbon Dioxide Extinguishers		Special			
24	Blankets (Wool)					
25	Blankets (Asbestos)					
26	Dry Powder Tubes		Not Approved			
27	Hand Grenades		Not Approved			

Int. Gen. Press. means Internally Generated Pressure.

e—If sand pails and sawdust are wet, they of course require protection against freezing.

f—Underwriters' Laboratories classification is based upon the following classes of fires:

Class "A," Quenching. Fires in ordinary combustible materials where the quenching and cooling effect of quantities of water, or solutions containing large percentages of water, is of first importance.

Class "B," Blanketing. Fires in small quantities of inflammable liquids, greases, etc., where a blanketing effect is essential.

Class "C," Non-conducting. Fires in electrical equipment where the use of a non-conducting liquid is of first importance.

g—Certain extinguishers, as Foam and carbon tetrachloride, are approved for two classifications.

h—The figures 1, 2, or 5, indicate number of pieces of equipment required to constitute one first aid fire appliance unit, which in turn is designed to afford protection for an average building over an area of 2,500 sq. ft.

i—Where no figures follow letters, in column 7, letters are used simply to show fires for which equipment is suitable.

SELECTION OF EQUIPMENT

3. The result of having such a variety of equipment from which to select has been that many properties have altogether too many kinds of equipment, and occasionally more than the conditions warrant. One important industrial plant has 11 kinds (of several types) of hand extinguishing apparatus, requiring not only almost technical knowledge to make a proper selection at the time of fire, but also keeping on hand a large variety of charges and spare parts. The average property can advantageously limit itself in hand extinguishing equipment to the following:

If buildings are sprinklered,

a—Inside hose (1¼-in. or 1½-in.) on sprinkler piping, and a few soda-acid extinguishers or water pails.

b—Or a more liberal supply of soda-acid extinguishers, or a combination of extinguishers and pails.

If buildings are not sprinklered,

a—Standpipes with 1½-in. hose and a few soda-acid extinguishers or water pails.

b—Or a more liberal supply of soda-acid extinguishers, or a combination of extinguishers and pails.

For special hazards,

For power house, dip tank, paint shop, oil house, garage, and similar hazards, an equipment of foam and carbon tetrachloride extinguishers, or sand or sawdust and soda mixture, or a combination of perhaps two of these in addition to the general protection.

4. Every plant should aim to standardize each class of equipment.

PROTECTION OF A TYPICAL BUILDING.

5. As an example of what is deemed good practice, a certain sized building is assumed and the protection which it could properly have is outlined. The rating schedules used by the Underwriters in different sections of the country generally specify, especially for mercantile buildings, the amount of equipment required to obtain rate reductions or to avoid charges for the lack of protection. Consequently, the Underwriters having jurisdiction should be consulted before important improvements are made.

6. The assumed building is 75 ft. wide, 200 ft. deep, 5 stories and basement in height, without attic, and of ordinary construction as regards floors, partitions, etc.

7. Pails filled with water to be provided in groups of five in store rooms, basement, and especially where combustible storage is present.

8. Two one-quart carbon tetrachloride extinguishers or five pails filled with sand, to be provided in power plant where electric machinery and oils are present.

9. From two to four soda-acid 2½ gallon extinguishers to be placed in halls in each story, including basement.

10. Two standpipes, 3 in. to 4 in. in diameter and carrying sufficient 1½-in. hose to enable all points to be reached with at least one stream, to be placed prominently in halls. Pressure to be sufficient to maintain at least thirty pounds in top story and water supply to be preferably from water works or from pressure tank.

11. If standpipes are to be used also by city fire department, diameter to be 6 in. and each standpipe to have in each story 2½-in. connections to which department can attach its own hose, these in addition to the 1½-in. private hose. Siamese connection to be provided for fire department use.

12. A summary of the requirements for this building is as follows:

Water Pails	20–40
Sand Pails	5
or	
Carbon Tetrachloride Extinguishers	2
Soda-acid Extinguishers	12–24
Standpipe Connections	12

ESSENTIAL FACTS REGARDING APPARATUS

13. The following brief statements regarding the principal advantages and disadvantages of interior fire-fighting apparatus are followed by detailed data:

14. Pails Filled with Water—Advantages: Low cost; ease of operation; readily understood; protection against freezing practical. Disadvantages: Maintenance difficulties; limited range; many portions inaccessible.

15. Pails in Tanks—Advantages: Reserve supply for pails; easily understood; protection against freezing practical; neat appearance. Disadvantages: Limited range; many portions inacessible; cost moderately high.

16. Casks Filled with Water—Advantages: Low cost; reserve supply for pails; protection against freezing practical. Disadvantages: Maintenance difficulties; limited range; many portions inacessible.

17. Hand Pumps—Advantages: Good range; reasonable discharge period; protection against freezing practical. Disadvantages: Cost moderately high.

18. Hose on Sprinkler Piping—Advantages: Good range; sustained streams; simplicity; relatively low cost. Disadvantages: Dependent on same water supply as sprinklers; not possible on dry systems.

19. Standpipes and Hose (Water)—Advantages: Good range; sustained streams; simplicity. Disadvantages: Cost high.

20. Soda-Acid Hand Extinguishers—Advantages: Good range; reasonable discharge period; easily maintained; stream carries gas and some salts. Disadvantages: Cost moderately high; operation not always understood.

21. Soda-Acid Engines on Wheels—Advantages: Replace standpipes to a considerable extent; good range; reasonable discharge period; stream carries gas and some salts. Disadvantages: High cost; difficulty of moving in some buildings.

22. Soda-Acid Standpipe Systems—Advantages: Approximately equal ordinary standpipe systems; minimum water damage. Disadvantages: Most systems not well developed mechanically; cost high.

23. Foam Pails—Advantages: Effective on ordinary fires; particularly effective on oil fires; readily understood. Disadvantages: Cost high.

24. Automatic Foam Cans—Advantages: Espcially designed for use over open dip tanks or similar containers. Disadvantages: Cost high.

25. Foam Hand Extinguishers—Advantages: Effective on ordinary fires; particularly effective on oil fires; good range; reasonable discharge period; considerable foam capacity. Disadvantages: operation not always understood; cost moderately high.

26. Foam Engines on Wheels—Same as Foam Hand Extinguishers; also large capacity replaces standpipes to considerable extent.

27. Foam Standpipe Systems—Same as Foam Engines on Wheels. Systems generally used outside of buildings.

28. Carbon Tetrachloride Extinguishers—Advantages: Effective on electric and some oil and chemical fires; compactness; non-freezing. Disadvantages: Cost moderately high; not advisable for general protection; operation not always understood.

29. Calcium Chloride Extinguishers—Advantages: Good range; reasonable discharge period; non-freezing. Disadvantages: Limited field experience; cost moderately high.

30. Sand (in Pails, Casks, and Bins)—Advantages: Low cost; efficient on oil and similar fires. Disadvantages: Hard to throw; caking; maintenance difficulties.

31. Sawdust and Soda—Advantage: Low cost; efficient on fires in heavy inflammable liquids. Disadvantages: Purpose not always understood; maintenance difficulties.

32. Steam Jets—Advantages: Effective on inflammable liquids and in dry kilns under favorable conditions. Disadvantages: Large steam supply required; tight building required; limited to moderate size structures; cost may be high.

33. Carbon Dioxide Gas Extinguishers—This refers to devices using gas as the extinguishing part. They are special and there is limited field experience.

34. Blankets (Asbestos or Wool)—Advantages: Exclude air from burning materials. Disadvantages: Maintenance difficulties.

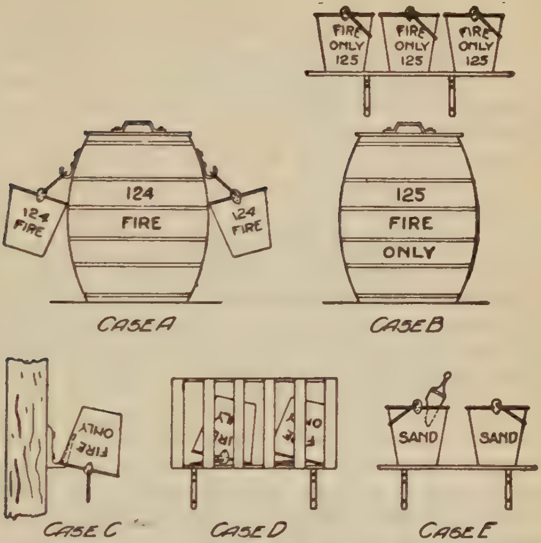
35. Dry Powder Tubes—Unsatisfactory record; not approved under any conditions.

36. Hand Grenades—Unsatisfactory record; not approved under any conditions.

PAILS FILLED WITH WATER.

37. It is generally admitted that more fires are extinguished by pails of water than by all other means combined. This is because everyone understands and instinctively uses the pail, and it can be almost instantly employed while the fire is still in its incipiency. Pails filled with water are effective on incipient fires in ordinary combustible materials (such as wood, paper, textiles, rubbish, etc.), i.e., on Class "A" fires, where the quenching and cooling effect of quantities of water or solutions containing large percentages of water is of first importance. They are of value also on incipient fires in floors, soaked with oils, greases, etc., where the quenching and cooling effect of the water may be utilized; but are not effective on fires in inflammable liquids, greases, etc., in vats, open vessels, etc., where the blanketing effect is essential.

38. The principal shortcomings of pail protection are the



For dusty locations coal breakers, etc and also outside use

SLATTED FRONT BOX Slats to be of light construction and broken in case of fire

For oil, paint, varnish, or electrical fires. Fine dry sand to be used. Provide scoop to assist in scattering sand.

CASKS
Capacity about 60 gallons. Old oil or paint barrels preferred. Provide with covers having handle Paint red and stencil "Fire or Fire Only" Coat inside with asphaltum if calcium chloride is used.

PAILS
Capacity about 12 quarts. Galvanized iron, flat or round bottom. Paint red and stencil "Fire" or "Fire Only."

FREEZING
3 lbs 75% calcium chloride crystals added to each gallon of water will withstand a temperature of about -9° Fahr.

Fig. 67. Arrangement of Water Casks and Pails
(Courtesy of Independence Bureau)

tendency to use them for domestic purposes, evaporation and fouling, and that they are judged unsightly for some locations. Furthermore, when used, all water in a pail is thrown at a fire at once, and there is no reserve, save more pails. It is also difficult or impossible to reach, with water from a pail, a fire burning within flues, behind sheathing, on overhead construction, or on high ceilings. Fouling can be retarded through the use of lime or charcoal placed in the water.

39. Types—12 qt. flat-bottom galvanized iron or steel or fibre pails, painted red on outside and stenciled "FIRE" or "FIRE ONLY" in black letters not less than $2\frac{1}{2}$ ins. high are commonly used. In some jurisdictions, Underwriters require pails having round or conical bottom, which of course should then be provided.

40. Numbers and Arrangement—The general rule of the National Board regarding the number of pails and their placing calls for not less than 5 to every 2,500 sq. ft. area, and pails to be hung on hooks or set on shelves arranged so that the bottoms of pails will not be less than 2 ft. nor the tops of pails more than 5 ft. from floor. Where other than flat-bottomed pails are used, the holes cut in shelves shall only be large enough to receive the oval or cone, and flanges of pails shall rest on shelf. Units (5 pails) should be so placed that the travel from any point to the nearest pails will not exceed about 35 feet. See Fig. 67 for suggested arrangement of casks and pails.

PAILS IN TANKS.

41. Metal tanks with covers, commonly called "Bucket Tanks," ranging in capacity from 22 to 40 gallons, and containing 5 or more nested pails, are in common use as a substitute for ordinary pails and for wooden casks and pails. The appearance of bucket tanks is neat, upkeep is easy, and by using calcium chloride freezing can be prevented. Tanks approved by the Laboratories should be purchased. A 22-gallon tank and 5 pails is considered a unit of protection.

PAILS WITH SEALED COVERS.

42. Generally speaking, the use of such pails is not advocated since their use is not obvious, they may get out of order, they cannot be readily repaired, and some are particularly liable to corrosion.

43. Certain types, however, after vigorous Laboratories and field tests have demonstrated their value as regards non-evaporation and non-freezing, and have been approved. Before purchasing it should be ascertained that the approval of the Laboratories has been obtained and that equipment is acceptable to the Underwriters having jurisdiction.

CASKS AND PAILS.

44. Old oil barrels of 50 to 60 gallons capacity are commonly used for a reserve supply for pails and are placed both inside and outside of buildings. Casks are properly painted red and stenciled similarly to pails, fitted with covers, and provided with three pails each. See Fig. 67. Casks have been placed in cast-iron pans on short legs in order that water leaking from casks might not cause dry rot in floors. A 50-gallon cask and 3 pails is considered a unit of protection.

HAND PUMPS.

45. The old-fashioned hand pump attached to a bucket of fair capacity, and capable of giving an effective stream as long as water was provided, has considerable merit. It combines efficiency and simplicity. Particularly well built pump tanks of 2½ and 5 gallons capacity have been approved by the Laboratories. Non-freezing solutions can of course be used.

NON-FREEZING SOLUTIONS.

46. Salt and Calcium Chloride—The objections to common salt used to prevent the freezing of water are: Inability to depress freezing point appreciably below zero degrees F., corrosive action, and tendency to creep and crystallize over the container.

47. Calcium chloride free from magnesium chloride is far superior under ordinary northern winter conditions, and its use is therefore advised. Because it reacts with bicarbonate of soda, calcium chloride must never be used in a soda-acid extinguisher.

48. The comparative freezing points of salt and calcium chloride solutions are shown in the following table:

FREEZING POINTS OF SOLUTIONS OF COMMON SALT AND OF 75 PER CENT. CALCIUM CHLORIDE

Pounds per Gal. of Water.	Pounds per Gal. of Solution.	Specific Gravity at 20° C.	Degrees Beaumé.	Degrees Salometer.	Freezing Point.		
					Calcium Chloride.		Salt Deg. F.
					Deg. F.	Deg. C.	
0.50		1.024	3	13			+ 24
1.00		1.055	6	27			+ 18
1.50	1.40	1.081	10	40	+ 31.0	− 0.5	+ 12
2.00	1.80	1.123	13	52	+ 14.4	− 9.8	+ 6
2.48	2.28	1.150	20	80	+ 7.5	− 13.6	+ 1
2.96	2.60	1.176	22	88	− 1.4	− 18.2	− 3
3.50	3.00	1.201	24	95	− 8.7	− 22.6	
4.08	3.40	1.227	26	104	− 21.8	− 30.0	
4.70	3.80	1.252	29	114	− 32.6	− 36.0	
5.35	4.20	1.277	31	121	− 50.0	− 45.5	
5.55	4.40	1.283	32	124	− 54.4	− 48.0	
6.00	4.60	1.303	34		− 39.0	− 39.5	
6.65	5.00	1.328	36		− 9.76	− 23.2	

49. The table assumes common salt in crystalline form and 75% crystalline calcium chloride as supplied commercially.

50. Forty per cent. calcium chloride solution (specific gravity 1.4) diluted with an equal amount of water will give a solution freezing at approximately —9° F.

51. The National Board regulations covering First Aid Fire Appliances put the facts regarding calcium chloride in somewhat different form, viz., amount of water and calcium chloride to make a given amount of solution.

Approximate Freezing Temperature Degrees Fahrenheit.	To make 2½ Gallons Anti-freezing Solution.			
	Water.	Calcium Chloride.	Specific Gravity.	Degrees Baumé.
10°	2 Gals. 1 qt.	5 lbs.	1.139	17.7
zero	2 Gals. 1 qt.	6½ lbs.	1.175	21.6
10° below	2 Gallons	7 lbs. 6 oz.	1.205	24.7
20° "	2 Gallons	8 lbs. 6 oz.	1.228	26.9
30° "	2 Gallons	9 lbs. 2 oz.	1.246	28.6
40° "	2 Gallons	10 lbs.	1.263	30.2

Note: This table is based on granulated 75% calcium chloride.

52. Casks to be able to withstand the penetrating power of calcium chloride solution must be well pitched inside. Even then they sometimes fail to hold the solution. Bucket tanks are, therefore, popular where the freezing danger exists.

53. Salt at the rate of one quart for a 2½-gallon **soda-acid extinguisher** is reported to depress the freezing-point to + 15° F. Its use is not advisable, largely because a cold extinguisher does not operate well. Calcium chloride cannot be used because it reacts with the soda.

54. Glycerine—The use of glycerine in chemical extinguishers will lower the freezing point to about 0° F., but it has the objection of high cost, of the possible decomposition of soda, and of creating a scum on the surface of the water which clogs the outlet, as well as the objection that the stream from a very cold extinguisher is very feeble.

55. Sulphuric Acid—This acid has a remarkable freezing curve. 66° B (oil of vitriol) is the customary strength for soda-acid extinguishers. It freezes at — 29° F. 65¾° B. freezes at — 1°; 65½° B. at + 13.4°; 64° B. at 46.4° F., and between 59° B. and 23° B. the freezing point is never higher than — 7° F. A small amount of moisture absorbed by oil of vitriol may cause the acid to freeze at a point higher than water. It has been recommended that 58° acid (made up at the plant if desired) and freezing below 0° F. be used. Only a little more would be needed in each extinguisher bottle than of the oil of vitriol strength. The strength of the acid should be ascertained with a special hydrometer. Fig. 68 shows the remarkable freezing curve of sulphuric acid.

HOSE ON SPRINKLER PIPING.

56. The automatic sprinkler rules permit the use of hand hose on *wet systems only* under the following conditions:

a—Pipe nipple and hose valve to be 1 in.

b—Hose to be 1½ in. or 1¼ in. in size.

c—Nozzle not to be larger than ½ in.

d—Hose not to be connected to any pipe smaller than 2½ in.

53. Such a hose connection is in effect a portable sprinkler and equipment of this kind is exceedingly desirable. 1½-in. unlined

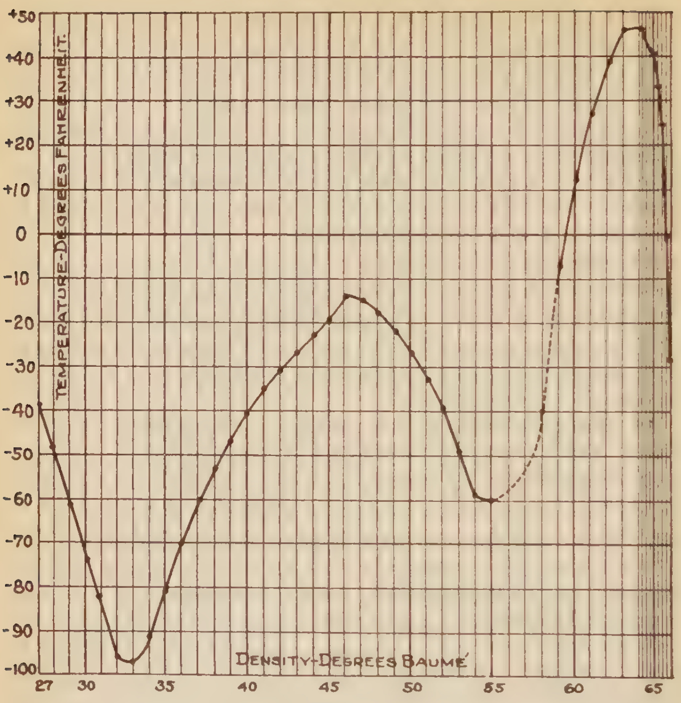


FIG. 68. FREEZING POINTS OF SULPHURIC ACID

linen hose is recommended. See next section for details of inside hose installations.

STANDPIPES AND HOSE.

57. Much valuable protection may be secured from standpipes and hose, particularly if buildings are not equipped with the much more expensive and efficient automatic sprinkler system. Standpipes have value for protection against exposure as well as for interior fires. Four things are necessary: A supply of water; installation of pipes, valves, and hose; constant maintenance; and persons available who have the knowledge and inclination to make prompt use of such facilities. See the specifications on standpipes in the 1917 N. F. P. A. Proceedings. See also article in the October, 1919, Quarterly regarding record of use of standpipes in New York City fires during 1914–1918.

58. There are two distinct divisions of this service, namely, small hose (1½-in. advisable size; 1¼-in. and 2-in. also manufactured) and the larger 2½-in. size as commonly used for outside hydrant streams. The former is altogether the more desirable for general use inside of buildings and the latter should seldom be employed; the chief exception being where professional fire department would promptly respond and attach its own hose to outlets provided for such purpose, or use the 2½-in. hose provided permanently within the building. Such an arrangement is particularly feasible in city buildings having fire-resistive stair shafts where the 2½-in. outlets can be provided on standpipes run up through these shafts.

59. Where it is necessary to have 2½-in. connections on standpipes, it is good practice to have 2½-inch × 1½ in. reducers (with lugs to make for easy removal), attached to the fire department outlets and 1½-in. hose connected for use by employees. The alternative is to have a 2½″ outlet for the fire department hose, and a 1½″ one with hose for use by the persons in the building.

60. Constant water pressure should be maintained on these hose systems, from adequate public water supply, pressure tank, or gravity tank. Fire pump, whether or not automatic, is not a fully satisfactory primary supply. If hose is to be used in the very first stages of a fire, it is important that the person going to the hose, taking it down, and opening valve, at once obtain a serviceable stream. Pressure tanks are recommended for the use of "small hose" service where an adequate public water supply is not available. The automatic sprinkler water supply rules should be followed for any such special tank installations.

61. In building where there is no provision for heating water in the piping during cold weather, the standpipe system can advantageously be put on a dry valve of the same type as used for automatic sprinkler service, or a special form of valve can be used, as set forth on page 604.

62. See preceding section for small hose attached to sprinkler pipes.

63. Water Supply—If standpipe system is to be used by city fire department, it is almost always necessary to install one or more fire department connections to which city steamers or high pressure lines can be attached.

64. Occasionally city water supplies are so good that streams from several stories can be concentrated upon a fire.

65. Water supply preferably should be sufficient to maintain not less than 30 pounds pressure at the topmost connection with two or three streams in action.

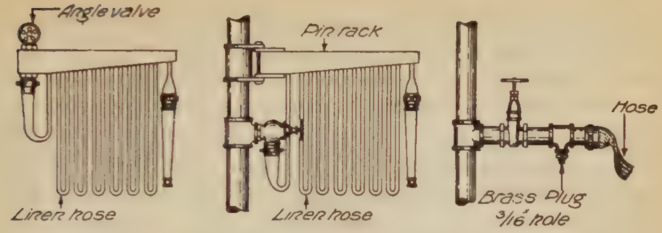
66. If meters are installed in city connections, the question of friction should be investigated. Fire service meters are generally advisable, or hose valves may be sealed by the water department and meters omitted altogether.

67. Standpipes—Size and Location—For 1½-in. hose, the diameter of a standpipe for a building of ordinary height is generally from 2-in. to 3-in. If a combination standpipe is provided, to which the fire department can attach its hose, the diameter should seldom be less than 6-in., and 8-in. may be proper for very high and important buildings.

68. If building has fire-resistive stair towers, especially if not connected directly to the various floors, these form the best locations for standpipes. Ordinarily standpipes are placed in halls and so located that it is possible to reach all points with a 50-ft. length of hose. 100-ft. lines are the maximum allowable.

69. Hose—This should be labeled unlined linen, preferably 1½-in. in size. If intended for fire department use, the 2½-in. size is customary, with threads to fit the public department. Hose should be in 50-ft. lengths, even if lines are 100 ft. long, and should be kept on flat fold or pin-racks. Semi-automatic racks, designed to be operated quickly by one persons, are approved. Reels are not recommended because of the difficulty of inspecting hose and of poor ventilation.

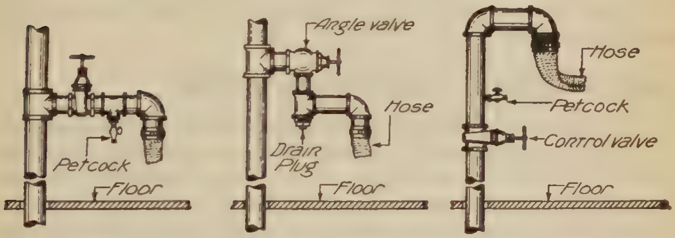
70. Straightway gate valves with drips or globe valves of the soft removable disk type are advisable for standpipe service. Fig. 69 shows various methods of protecting hose against leaking valves. Case E shows such a drip for an angle globe valve, al-



CASE-A
Angle globe valve, pin rack on valve nipple. No drip.

CASE-B
Angle globe valve without drip. Pin rack fastened to riser.

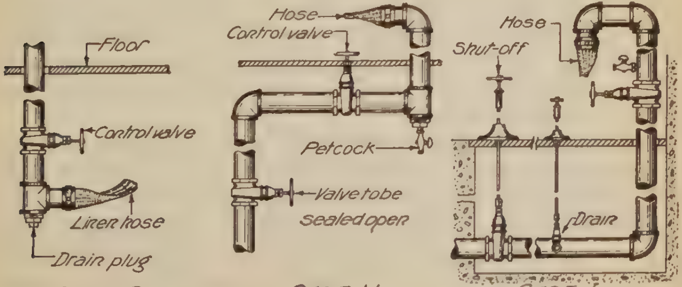
CASE-C
Gate valve and drip.



CASE-D
Same as Case-C with down-turned outlet.

CASE-E
Angle valve with drain.

CASE-F
Connection for top story.



CASE-G
Connection for basement.

CASE-H
Roof connection. Valve in heated story.

CASE-I
Valve control for unheated buildings.

FIG. 69. ANGLE GLOBE VALVES AND DRIP CONNECTIONS USED TO PREVENT LEAKAGE ENTERING HOSE
(Courtesy of Independence Bureau)

though the general opinion is that such valves give virtually no trouble from leakage. Unlined linen hose if kept dry will last almost indefinitely. It should never be used except in case of fire. The practice of testing it periodically is decidedly bad.

71. The advantages of unlined linen over cotton rubber-lined hose are that it is not affected by heat; it occupies a smaller space; it is lighter; it does not require testing, and it costs materially less money.

72. Brass or iron nozzles are used with orifices to fit the diameter of hose and the available pressure. For 1½-in. hose, ½-in. to ⅝-in. nozzles are ordinarily used, and for 2½-in. hose 1-in. to 1⅛-in. nozzles are usually provided. Smooth tapered rather than ring nozzles are recommended. Painting brass nozzles gives some protection against theft.

NON-FREEZING STANDPIPE SYSTEMS.

73. In unheated buildings such as warehouses, car barns, steamship piers, and grain elevators, the problem of providing standpipe service has always been complicated by the fact that no pipe and valve covering can be relied upon to protect water in piping against freezing in event of protracted cold spells. The possibilities of procedure if there is to be effective standpipe protection are:

a—System shut off at point below frost line, controlled by gate valve or valves, and piping normally drained. This is feasible in a 1-story building, such as a car barn, where each hose connection is controlled by a separate valve. See Fig. 69. In a multi-story building, the use of a very long valve operating rod has been tried, but is of doubtful value.

b—A regular automatic sprinkler dry pipe valve used for standpipe system, and system kept full of air under pressure, is satisfactory and has had considerable field experience.

c—The use of a dry system and a special quick-opening valve operated by electricity or air. One system, the Cornell-Derby of the W. G. Cornell Co., uses an electric release at the valve, and operates this release manually from each hose station. Another system, that of the "Automatic" Sprinkler Corporation of America, uses a "rate of rise" device to trip the valve. A fire within the area protected automatically turns on the water, which can be used from any hose connection.

SODA-ACID HAND EXTINGUISHERS.

74. The soda-acid hand extinguisher is strong where the pail is weak, and the two supplement each other effectively.

75. The 2½-gallon net capacity (3 gallons gross capacity) upset-to-operate soda-acid extinguisher is thoroughly standardized and well over 1,000,000 are in use in this country. It furnishes in incipient fires a small jet of water under high pressure, reaching a point from 30 to 40 ft. from the operator, and lasting, if continued in use, for about one minute. The jet carries some carbonic acid gas and sulphate of soda and usually some bicarbonate of soda, and to some extent deposits soda salts on the burning mass, forming a partial coating which tends to exclude the air and to retard combustion. These extinguishers are particularly useful for fires in concealed construction and boxed machines, in which case the extinguishing powers of the gas become available.

76. At ordinary temperatures, an extinguisher generates about 100 lbs. pressure on being upset. Higher pressures are produced if the water is very warm.

77. For use in homes, schools, and at other points where women and children are expected to operate extinguishers, the 1½-gallon net capacity size is recommended.

78. Extinguishers should be hung from hooks with tops about 5 ft. from the floor. They are readily upset and partly or entirely discharged if resting on floors or shelves.

79. Annual discharging, cleaning, and recharging is recommended, partly to insure the operation of the extinguishers, and partly to give employees and others an opportunity to operate them or see them used. A recent development has been a design of extinguisher cover which largely eliminates the difficulties often encountered in removing caps.

80. Extinguishers must be protected against freezing. In cold weather they must be placed where there is heat or heated cabinets must be provided. Hair-felt lined boxes are not effective for protracted cold spells.

81. Break bottle and compressed air type extinguishers are not recommended.

82. Approved, tested, and labeled extinguishers only should be purchased. Poorly designed and constructed extinguishers have repeatedly burst and cause loss of life or serious injury. Any extinguisher shell which shows any appreciable corrosion inside or out should be returned to the manufacturer, and, if in his judgment unsafe, should be discarded. Any extinguisher shell burst or seriously stretched by freezing should be scrapped.

NON-FREEZING EXTINGUISHERS.

83. Throughout some properties, and in portions of almost all properties, there are situations where it is desired to use a chemical extinguisher and where freezing temperatures prevail during a portion of the year. It is not possible with the ordinary soda-acid extinguisher to use any chemicals in the tank which will depress the freezing point sufficiently for cold climates, and besides chemical reaction is always slow in the soda-acid extinguisher in which the ingredients are cold. The following records the past and present practice:

a—Compressed air extinguishers have always proved unsatisfactory, because of the difficulty of maintaining the pressure over long periods of time.

b—Extinguisher carrying a capsule of liquid of carbon dioxide gas, with diaphragm punctured when it was desired to operate extinguisher, has given fairly good field service. The tank is filled with a calcium-chloride solution.

c—An approved anti-freeze type of extinguisher operates by inversion, whereupon through a percussion cap, fire is set to a slow-burning fuse. The resultant gases give adequate pressure to drive out the calcium-chloride solution with which the tank is filled.

d—A more recent development has been the provision of a gas generator tube containing two non-freezing chemicals, which upon inversion provides gas to drive out calcium-chloride solution. It is said that this generator tube can be placed in virtually any soda-acid extinguisher.

SODA-ACID ENGINES ON WHEELS.

84. Soda-acid engines on wheels are of much value at certain properties where standpipe and hose service is not available, as in freight and express sheds, piers, public buildings, and country estates. They are particularly useful where there are large areas and comparatively smooth floors. Where elevator service and width of doors permit, they can be transferred to different floors.

85. The 33-gallon net capacity size is the one ordinarily used, and approval on such engines has been obtained from the Underwriters' Laboratories. The commonest form is the two-wheeled warehouse type, which ordinarily rests upon the bottom, the wheels just clearing the ground, and which must be tipped about 30° from the vertical before the wheels strike the floor and enable the engine to be run to the fire. When the fire is reached, the engine is inverted, and the acid automatically thrown into the soda solution. For yard use, the horizontal tank, truck form, wide gage type of engine is best. In principle, such an engine is similar to the small upset type hand extinguisher. These engines do not differ in operation or effectiveness from the chemical tanks used by public fire departments, and, as is well known, the city departments succeed in extinguishing a large majority of all fires with chemical apparatus.

86. There are poor, unsafe machines upon the market. Competent fire protection advisors should be consulted before purchasing any equipment which does not bear the Laboratories' label.

SODA-ACID STANDPIPE SYSTEMS.

87. Soda-acid standpipe systems, fed by stationary tanks, occasionally of several hundred gallons' capacity, are employed where the lack of water supply bars the ordinary standpipe installation. They have also beeen used to supply a moderate number of automatic sprinklers, especially in locations where the liquid and the gas discharged from such a tank may be expected to be more efficient than plain water.

88. Many of the older installations have proven unreliable owing to mechanical defects, corrosions, freezing, and failure to be properly operated.

89. Some years ago a standpipe was approved which operates by the release of a moderate air pressure (with which the tank and piping are filled), when a valve or sprinkler head is opened. The differential pressure, between the tank and the piping, acting through a piston upsets the acid into the soda solution.

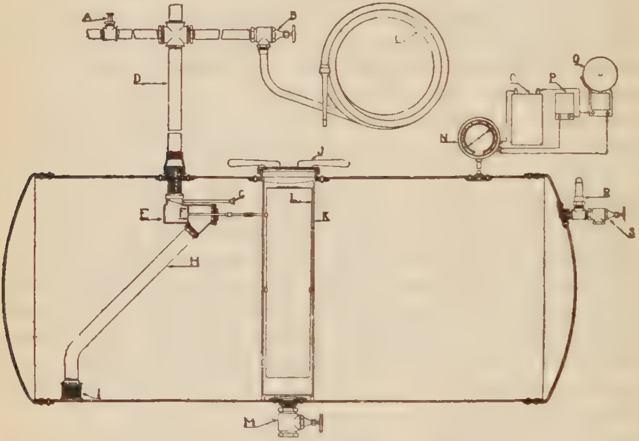


Fig. 70. Relc Chemical Engine

90. The operation of the Relc chemical engine shown in Fig. 70 is as follows:

The stationary tank is approximately five sixths full of the customary soda solution. The acid bottle (L) is mounted on trunnions and is kept in a vertical position by the rod attached to the piston (F). The tank and the standpipe system are filled with air under moderate pressure, the pressure on both sides of the piston being equalized through a small hole in the gold plate shown at (G). Gold is used to prevent corrosion. The opening of a sprinkler head, as at (A), or the turning on of a hose valve, as at (B), unbalances the pressure, causes the piston (F) to move horizontally, upsets the acid bottle, and the liquid is then discharged through the strainer (I) and outlet pipe (H). The pressure in the system necessary to operate it is stated to be less than one sixth of a pound.

FOAM PAILS.

91. The approved form of foam pail consists of a heavy galvanized iron bucket, in the center of which is a receptacle for holding the acid solution. The basic solution is between the acid receptacle and the shell of the bucket. Bucket normally is covered. Upon operating, lid is removed, and contents are cast upon the fire. The two solutions mix partly in the air and partly as they strike, and a 3-gallon pail makes about 20 gallons of foam.

AUTOMATIC FOAM CAN.

92. An approved can of 3½-gallon liquid capacity is suspended not to exceed 5 ft. above the surface of a tank containing inflammable liquid. Each can will protect an area not exceeding 16 sq. ft. The can contains a "rate of rise" release, a quick-operating valve, and produces between 25 and 30 gallons of Foam.

FOAM HAND EXTINGUISHERS.

93. Approved Foam extinguishers, operate similarly to soda-acid extinguishers, and have a similar appearance. Liquid capacity is 2½ gallons. Chemicals used are bi-carbonate of soda and foam-producing agents dissolved in water in an outer compartment, and aluminum sulphate dissolved in water in the inner cylinder.

94. Foam extinguishers will do practically everything which a soda-acid extinguisher will do, and in addition have great value for fires in inflammable liquids. In fact, they constitute the most effective method of controlling such fires.

Up to the present there has not been developed any non-freezing type of Foam extinguisher.

FOAM ENGINES ON WHEELS.

95. Foam engines on wheels operate on the same principle as Foam hand fire extinguishers, and what is said regarding soda-acid engines on wheels applies largely to Foam engines as well.

96. Approved engines are of 33-gallon liquid capacity, and capable of delivering approximately 320 gallons of foam, and consequently they can be relied upon to handle an oil fire of reasonable area. These engines must also be protected against freezing.

FOAM STANDPIPE SYSTEMS.

97. One interesting use of the Foam engine has been to place a 33-gallon tank on trunnions and support it with an electric release device. Through a hose and pipe connection the engine is attached to a Jumbo (1¼″ orifice and strut removed) sprinkler head over a dip tank. This head is placed not over 8 feet above the dip tank and a deep curtain board is placed at the ceiling, with enclosed area larger than that of dip tank. Over this dip tank also is placed a thermostat, which, in event of fire, operates the electric release, permits the engine to invert, and discharges foam through the Jumbo sprinkler.

98. While it is possible to install a stationary Foam system to supply standpipes in buildings, the use of the stationary foam apparatus is primarily in connection with protection of oil refineries and similar properties. See page 425.

CARBON TETRACHLORIDE EXTINGUISHERS.

99. Within the last decade the use of the carbon tetrachloride extinguisher has become widespread. One quart and one and a half quart extinguishers are approved. Larger extinguishers have been manufactured and even automatic sprinkler systems using carbon tetrachloride have been installed in certain locations, as, for example, to protect against fire in inflammable liquids and to extinguish fires in large oil-insulated transformer cases.

100. In spite of the fact that carbon tetrachloride extinguishers are limited by Underwriters' Laboratories to fires of the blanketing and non-conducting type, such extinguishers have been sold widely for general protection. Since they work upon the exclusion-of-air principle, rather than by the wetting down and cooling principle, they are not most effective for ordinary types of fire, although of course many such have been extinguished by them.

Carbon tetrachloride extinguishers are unquestionably best for motor, street and railway cars, and for electric fires. They are valuable on fires in volatile liquids, providing the burning area is decidedly limited.

101. Tests by the Bureau of Mines and the Underwriters' Laboratories have shown that, upon contact with high temperatures, carbon tetrachloride will break up, producing in part highly poisonous gases. See N. F. P. A. Quarterly of January, 1921. The practical aspects of the problem, however, are that this is not a serious matter, and should not mitigate against the use of these extinguishers in those locations where fires for which they are suitable are likely to be encountered.

102. Only extinguishers bearing label of Underwriters' Laboratories should be purchased. They should be partly discharged and recharged annually. Under no consideration should water be used to test an extinguisher which has had carbon tetrachloride in it, as the chemical reaction between water and carbon tetrachloride produces hydrochloric acid with destructive results from a corrosion standpoint.

PAILS FILLED WITH SAND.

103. For inflammable liquids, grease, and electric fires, sand has considerable value, providing the area of the fire is not too large, and providing sand does not sink to the bottom where liquid is of some depth. Fine dry sand is best. Where gritty action of sand is feared, barytes and soapstone have been used successfully. Soda should not be used because it cakes too readily.

104. To assist in distributing sand, large metal scoops can be used except for high voltages, under which conditions scoops should be entirely of fibre or wood or should at least have a wooden back and handle.

SAND BINS.

105. Because of the difficulty of shoveling sand out of a cask, it is generally advisable to use bins for storage of large supplies, marked as are casks, and provided with large metal shovels to distribute sand. Wooden or fibre shovels are used where voltages are high. See Fig. 71 for an effective method of storing larger quantities of sand.

106. Earth, ashes, and other similar substances may of course be used in lieu of sand.

SAWDUST AND SODA.

107. Tests by the engineers of the Factory Mutual Laboratories have borne out the fact that a mixture of sawdust (no particular kind is best) and bicarbonate of soda, at the rate of 10 pounds of soda to the bushel, has remarkable extinguishing powers on fires in inflammable liquids even in open tanks of considerable size and containing comparatively large quantities. This mixture floats on the surface and cuts off the oxygen supply. Sand naturally sinks through to the bottom and is useless. Such protection is recommended for lacquers, varnishes, and similar liquids. The mixture should be kept on hand in ample quantities in bins and distributed with long-handled shovels of large area.

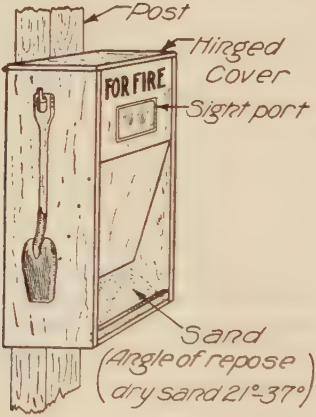


Fig. 71. Sand Box on Post

Same principle applicable to other locations

STEAM JETS.

108. Steam jets have been commonly provided for dry kilns, shaving vaults, and similar special hazards where water from hose streams or sprinklers could not readily reach the fire, and occasionally for oil storage and dip tank rooms and other points where water might not be effective. The use of steam as protection against internal and exposure fires for oil storage tanks is old. Most systems are likely to fail because of insufficient steam supply and lack of tightness of building or tanks into which steam is discharged. No systems should be installed without careful investigation and calculation. An outlet pressure of not less than 15 pounds is deemed essential.

109. Safely located control valves are an important factor.

110. Automatic sprinkler heads on trapped piping filled with water, with steam exerting pressure on this and discharged from system as soon as water is forced out, are occasionally used so as to give automatic control.

CARBON DIOXIDE EXTINGUISHERS.

111. For decades the idea of using carbon dioxide gas as an extinguishing agent has come up for periodic consideration. While devices have been manufactured to meet different situations, carbon dioxide gas has had relatively little actual use in the field. Some experiments, fairly successful, have been made in connection with telephone switchboard fire extinguishing. Also drums of liquid carbon dioxide gas have been connected to a header, from which in turn pipes led into tops of oil-insulated transformers, so as to enable the space above the oil to be filled with inert gas in event of fire outbreak. The difficulty of such a scheme is the freezing of the outlet valve, owing to the great cooling of the expanding gas.

112. During 1922, the Hartford Electric Light Co. completed an automatic carbon dioxide gas system for handling fires in large electric generators. Tests have indicated that the addition of 10% of inert gas to air will prevent it from supporting combustion.

113. A more common method of handling fires in electric generators is to provide at each end of the rotating field a system of perforated pipes through which water or steam can be admitted after fire outbreak. In a number of instances, large turbines have been saved from serious damage through the use of large quantities of water through hose streams.

BLANKETS.

114. Asbestos mats or blankets are reported to have proved valuable in fire tests by smothering burning volatiles in pans of moderate size.

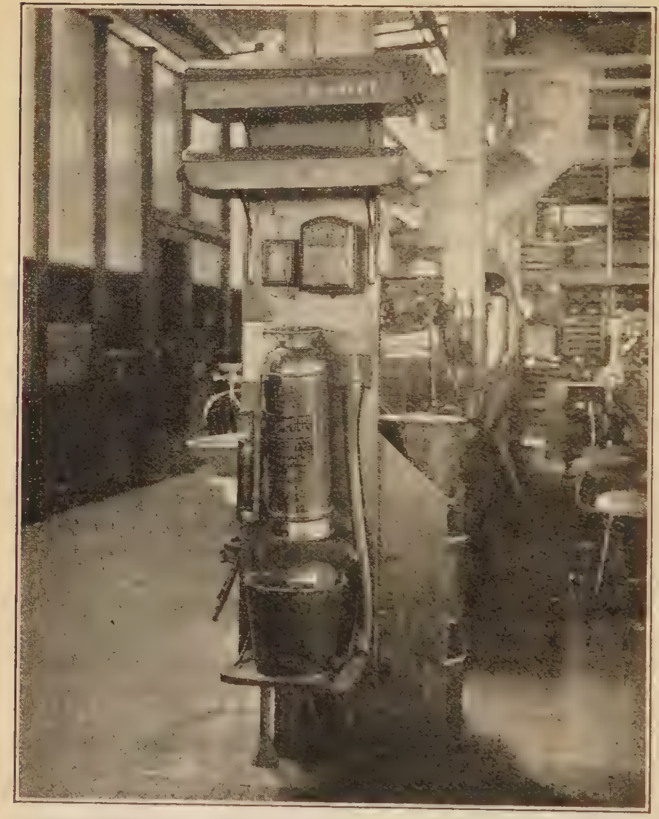


FIG. 72. GROUPING OF FIRE APPARATUS

(Courtesy of Eastman Kodak Co.)

At this column are the following: Soda-acid extinguisher, carbon tetrachloride extinguisher, 3 water pails, one sand pail with scoop, axe, waterproof cover, fireproof blanket, watchman's call box, fire alarm box, and drinking fountain.

115. Pure wool blankets are the best agents for smothering fire in clothing, and one or more blankets are advisable in chemical laboratories and at other points where the danger of the ignition of clothing is considerable.

116. Blankets should be so folded as to admit of ready opening. They should preferably be kept in dust tight glass front cabinets at prominent points.

DRY POWDER TUBES.

117. The National Fire Protection Association circular on this subject reads as follows:

> "In view of the fact that several so-called fire extinguishers, consisting generally of sheet metal tubes filled with mixtures of bicarbonate of soda and other materials in powdered form, have been widely advertised as suitable for use for fire extinguishing purposes, this committee has to report that in its opinion all forms of dry powder fire extinguishers are inferior for general use, that attempts to extinguish fires with them may cause delay in the use of water and other approved extinguishing agents, and therefore their introduction should not be encouraged."

118. The disaster in 1903 at the Iroquois Theater has been attributed to the use of a dry powder tube on the burning scenery in the initial stages of the fire when a small hose stream or a soda-acid extinguisher could almost certainly have extinguished the blaze. Dry powder tubes have no legitimate place in fire protection.

HAND GRENADES.

119. Glass bottles filled with chemical solutions and designed to be hurled at the seat of the fire are practically obsolete. They never were an effective fire-fighting agency, and they belong in the scrap heap or in the museum.

PROMINENCE OF APPARATUS.

120. In installing permanently placed as well as portable apparatus it is most important that it be located so as to be prominent and readily accessible. Fire apparatus is in addition generally painted red. It is astonishing to find how the rank and file of employees frequently do not know the whereabouts of equipment. If in halls, at doors through dividing walls, and in main aisles it must be seen.

121. Fig. 72 shows the practice of the Eastman Kodak Company at Rochester, N. Y., of not only grouping apparatus at one point but of putting a drinking fountain and watchman's box close by so that by day and by night people are forced to come to this station.

PROTECTION AGAINST WATER DAMAGE.

122. The damage by water, even with the most effective handling of a fire, frequently exceeds that done by fire. Important industrial plants have salvage corps attached to their private fire-fighting organizations, and use tarpaulins to cover up threatened stock.

123. Tarpaulins can advantageously be made of No. 250 Brown drill, given two coats of a preparation composed of four gallons of Calcutta raw linseed oil mixed with one half pint of lithia; this takes one hundred and twenty days to dry thoroughly. A better preparation, giving longer life to the covers, and better waterproofing is obtained by using a mixture, as follows: four gallons of Calcutta raw linseed oil, one half pint of dryer, one half pint of lithia, one half pint of turpentine, and one half pint of bees wax melted and then stirred into the mixture. Each cover to receive two coats, which will dry and be ready for use in sixty days. Advisable practice includes:

a—Using tarpaulins about 12 × 18 feet.
b—Providing them with liberal number of grommets for hanging and handling purposes.
e—Folding tarpaulins so they can be opened up in quickest possible time.
d—Drilling salvage corps or all members of the private brigade in handling tarpaulins. See page 416.

124. Sawdust is commonly provided to soak up water, and it is generally carried in metal or fibre barrels on wheeled trucks or located in convenient bins. Where storage is not provided on each floor, provision must be made to transfer it from floor to floor by means of elevators.

125. Sweeping water toward elevators or stairs is usual practice.

126. Skids for stock, at least 4″ high, give considerable protection to goods against water damage. Skids are especially needed in basements or where facilities are not good for rapid drainage of water. Scuppers reduce water damage.

CHAPTER 29

AUTOMATIC SPRINKLER PROTECTION

1. Sprinkler protection in its general phases is treated in this chapter, and various special phases of the problem in the following ones:

Chapter 30, Rules and Requirements for Automatic Sprinkler Systems.
Chapter 31, Alarm Valves for Automatic Sprinkler Systems.
Chapter 32, Dry Valves for Automatic Sprinkler Systems.
Chapter 33, Sypho-Chemical Sprinkler System.
Chapter 34, Open Sprinkler Systems.

2. The subjects treated in this chapter include the following:

a—Development of Sprinkler Protection.
b—Elements of Sprinkler Protection.
c—Fire Record.
d—Maintenance and Inspection.
e—Efficiency of Automatic Sprinklers.
f—Special or Modified Systems.
g—Partial Systems.
h—Basement Systems.
i—Supervision and Care of Valves.
j—Sprinkler Leakage.
k—Corrosion of Automatic Sprinklers.
l—High Degree or Hard Sprinklers.
m—Field Tests and Inspections.
n—Combined Heating and Sprinkler Systems.
o—Grinnell Silica Bulb Sprinkler.
p—Photographs of Sprinklers.

DEVELOPMENT OF SPRINKLER PROTECTION

3. The automatic sprinkler is by far the most important of all fire protection devices. A thorough understanding of this class of protection is therefore essential to the fire protection engineer and its history is also of more than ordinary interest. With the increase of values and hazards in our manufacturing plants came the need of better protection against fire, but while this was thoroughly recognized, comparatively little headway was made in reducing the fire loss on the individual plants until the advent of the automatic sprinkler. The difficulty of throwing water on the seat of the fire was often demonstrated and such simple fire protection as water pails, standpipes and hose, or even outside hose service, proved inadequate, unless the fire was discovered in its early stages.

4. The forerunners of the automatic sprinkler were the perforated pipe and the open sprinkler, which were installed in a number of mill properties from 1850 to 1880. The perforated pipe system, as its name implies, was simply a series of pipes with small perforations, attached to the ceiling and divided into sections, one or two to the floor, each fed by a main pipe or riser and controlled by a gate valve, generally located outside the room or building. It is evident that with this system there was a great waste of water, as well as poor distribution, and, furthermore, the systems were not in any sense automatic.

5. Next came the open sprinklers, which were attached to piping similarly located and consisted of metal bulbs with numerous perforations, intended to distribute the water over a given area. These systems were divided into sections and were controlled by outside valves, the same as the perforated pipe system.

6. The idea of automatic sprinkler protection, that is, a system where the heat from the fire releases the sprinkler head and allows the water to flow, dates back to 1860, if not before, but its practical application, so far as this country is concerned, dates from about 1878, at which time the Parmelee sprinkler was first installed. This sprinkler, while very crude when compared to modern devices, gave generally good results and proved conclusively that automatic sprinkler protection was both practical and valuable. However, the rapid commercial development of the automatic sprinkler began with Frederick Grinnell, who, first with the Providence Steam and Gas Pipe Company, and later as the founder and head of the General Fire Extinguisher Company, was more closely identified than any other man with the growth and improvements in automatic sprinkler protection. The first sprinklers bearing his name were used in 1882 and the Grinnell Glass Disc Sprinkler has, with relatively slight changes been in use since 1891 to the present time.

7. The Grinnell Co. Inc., are now putting on the market an entirely new type of sprinkler using a Silica Bulb in place of the soldered strut. This is illustrated and described on page 501.

8. At this writing there are twenty-three types of approved sprinklers, all of which have undergone the most rigid tests before being accepted by the fire underwriters of the United States.

9. Pages 502–06 show in cross section most of the approved automatic sprinkler heads. Photograph of these heads will also be found in the collection at the end of the chapter.

ELEMENTS OF SPRINKLER PROTECTION

10. The automatic sprinkler, as its name implies, is a device for automatically distributing water upon a fire in sufficient quantities either to extinguish it entirely or hold it in check in case the fire is located where it is impossible for the water spray to reach it. The water is fed to the sprinkler through a system of iron piping, ordinarily attached to the ceiling, the sprinklers being placed at intervals along the pipe. The sprinkler itself consists of an orifice or opening approximately one-half inch in diameter, which is normally closed by a disc or cap, held in place by a strut or levers of metal, held together with a fusible solder, which melts at approximately 160° F. in the ordinary or "low test" sprinkler. Attached to the frame of the sprinkler is a "deflector" or "distributor," against which the water is thrown with force and converted into a heavy water spray designed to cover or protect a certain area. (See pages 502–06.)

11. When the solder melts, due to the heating of the air around it, the strut or levers are released and the water is discharged through the opening against the deflector. It is evident that the amount of water discharged depends on the water pressure, as the opening is always the same, and five pounds of working or flowing pressure is generally considered a minimum for the proper action of the sprinkler. At this pressure the sprinkler will discharge about 12 gallons of water per minute, covering a floor area of more than 100 square feet, which is the maximum area allotted to each sprinkler under the best type of construction. See page 717, for gallons of water discharged from automatic sprinklers at various pressures. The deflector of the sprinkler is designed to throw water in all directions, including upwards against the ceiling, but it is evident that the water could not cover the entire area of the ceiling without an excessive waste at the sides, the purpose being to keep as much water as possible within the space allotted to each sprinkler head.

12. The arrangement or spacing of the sprinklers is according to well-defined rules based on a long and extensive experience. The average area covered by a sprinkler is about 80 square feet, or say 10 feet by 8 feet, depending on the construction of the building. The rules also cover the sizes of pipe to be used, method of hanging the pipe, and all other details connected with the installment of a complete system.

13. It is evident that a sprinkler system depends for its effectiveness on water in sufficient volume and proper pressure. Many a system has failed to do what was expected of it because of the lack of water.

WATER SUPPLY.

14. The different kinds of water supply are treated in some detail in the Chapter 26 on Water Supply for Private Protection.

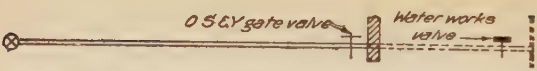
15. Generally speaking, a static pressure of 25 pounds at level of top line of sprinklers or a flowing pressure of 15 pounds should be considered the minimum for best service. The minimum volume usually varies with the class or kind of water supply, it being assumed that with a heavy pressure supply less water is required. This latter is doubtless true to a certain extent, but under normal conditions it is doubtful if there is much advantage in having the working pressure exceed 25 pounds. Very little water is actually required in most sprinkler fires, probably a few hundred gallons only in the majority of cases. Only a small per cent. of fires would require as much as 10,000 gallons of water, but larger volumes are usually required by the insurance interests, particularly if the property or value is large.

16. Most rating boards and underwriters require abnormally large water supplies, as they desire to be on the safe side, and it is, of course, true that under unusual conditions these large or excessive water supplies are at times needed. With a standard sprinkler system and the "ordinary" plant, the amount of water required by rating organizations would probably be between 10,000 and 25,000 gallons, increasing to 50,000 or even 100,000 gallons in the large or "unusual" plant. Such a large volume of water provides a very large "factor of safety," for it is probable that 75 or 80 per cent. of the fires in sprinklered plants have been extinguished or held in check with less than a thousand gallons of water.

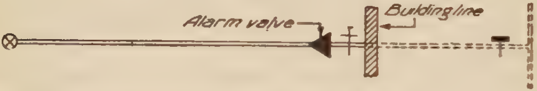
17. For standard protection it is generally considered necessary to have two satisfactory independent water supplies. At least one supply must be automatic, that is, able to supply a given volume of water under satisfactory pressure when the sprinkler opens, without manual aid. The second supply need not be automatic as it is assumed that the primary supply will at least hold the fire in check until human aid is available. If the primary supply is satisfactory both as regards volume and pressure, and practically free from interruption of service, the second supply becomes relatively unimportant. A second supply is of importance when the first supply is subject to interruption of service, and also to back up a primary supply which is weak or doubtful either as regards volume or pressure.

18. Waterworks systems or large reservoirs may provide an excellent primary supply with little need of a second supply. A weak waterworks system should have a pump or gravity tank as its second supply. A pressure tank, having a smaller or limited volume, should ordinarily have a second supply such as a pump or gravity tank. Fig. 73 shows various methods of supplying automatic and also open sprinklers through waterworks connections, gravity tanks, and fire department connections.

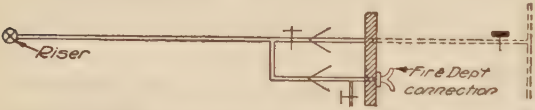
19. Automatic pumps of the centrifugal type, electrically driven, have been developed to a high state of efficiency and reliability. A recent development is the so-called "Booster Pump" with Supervisory Service. This system, with the pump taking water from



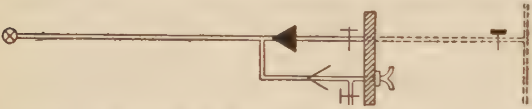
CASE-1. Simplest connection



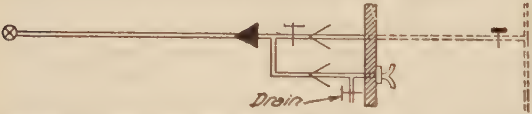
CASE-2. Same as Case-1 with Alarm valve



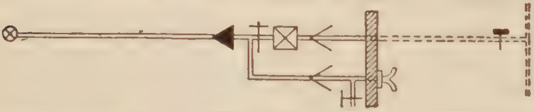
CASE-3. Water works and Fire Dep't connections



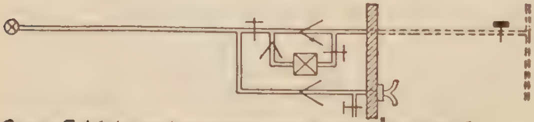
CASE-4. Same with Alarm valve acting as check.



CASE-5. Same with Alarm valve and check.

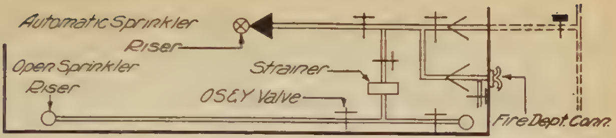


CASE-6. Meter requiring check valve -"TRIDENT-PROTECTUS"

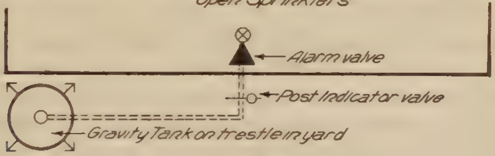


CASE-7. Meter not requiring check valve.-"HERSEY"

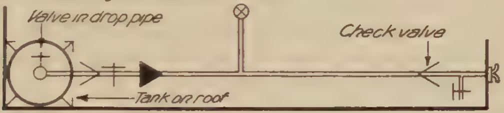
FIG. 73. SOURCES OF SPRINKLER SUPPLY
(Courtesy of Underwriters' Association of the Middle Department)



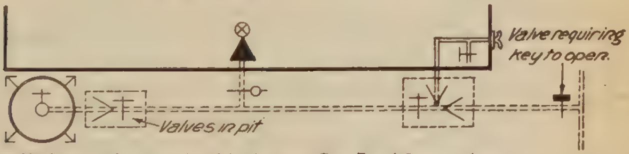
CASE-8. Water works and Fire Dept Connection feeding Automatic and Open Sprinklers



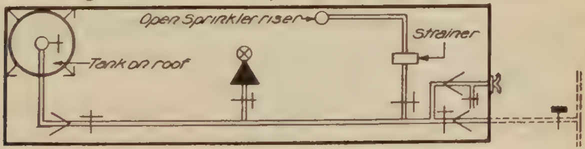
CASE-9. Gravity Tank as Sole Feed



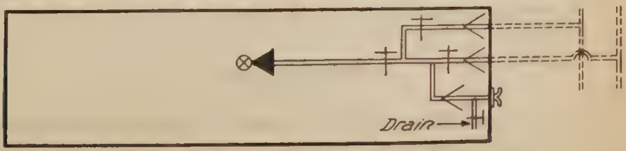
CASE-10. Gravity Tank and Fire Dept Connection as Feeds. Check valve not needed if Alarm valve acts as check.



CASE-11. Gravity Tank, Water Works, and Fire Dep't Connections



CASE-12. Same as Case-11, except also feeding Open Sprinklers.



CASE-13. Feed from Separate Water Works Connections.

FIG. 73. SOURCES OF SPRINKLER SUPPLY
(Courtesy of Underwriters' Association of the Middle Department)

low pressure city mains, is considered satisfactory and reliable even when used without any other water supply. See page 371.

FUNDAMENTAL PRINCIPLES.

20. A few of the cardinal principles of sprinkler protection may be here enumerated:

a—The distribution of water must be practically unobstructed, so that the seat of the fire may be reached by the water spray. It is, of course, evident that in many cases there will be some obstruction, but in practically all instances it is entirely feasible to eliminate all important features of this nature. For instance, sprinklers should be placed inside all enclosures, also under decks, platforms, etc.

b—Stock should never be piled around the sprinklers and thus obstruct the distribution of the water.

c—The sprinklers should be kept clean and never covered with paint or similar material, for this may affect their sensitiveness, or even render them entirely inoperative.

d—Floor openings should be protected to prevent draught, for while such openings may not cause a failure of the sprinkler system, the heat is liable to spread and thus open up a larger number of sprinklers than is necessary and possibly overtax the water supply, to say nothing of the increased damage from smoke and water.

e—Concealed spaces in floors or walls are also a menace, for fire may originate or spread in these spaces where water from sprinklers cannot penetrate.

f—The sprinkler system becomes of no value if for any reason the water supplies are not in service, as for instance in the case of a closed valve. The system must be at all times maintained in good working order, with all valves open.

FIRE RECORD

21. The remarkable results obtained by automatic sprinklers in the extinguishment of fires are difficult to appreciate unless carefully studied. Even with the older types of sprinklers which are no longer approved, the failure of the sprinkler head itself was very infrequent, and the failure of the modern types under normal conditions is practically unknown.

22. The best proof of the wonderful results is that the reduction in insurance cost when sprinklers are installed probably averages at least 75 per cent. and frequently is as high as 85 or 90 per cent.

23. This large reduction in insurance premiums has in many cases been the prevailing reason for installing automatic sprinklers. Oftentimes the annual saving is sufficient to pay for the sprinkler system in two to four years; it seldom takes over seven or eight years. Leaving out of consideration the question of safety, which should be the most important feature, the property owner finds this form of protection an excellent investment.

24. Assume a mercantile property with an insurable value of $300,000 building and contents, and an average rate of 1 per cent. If there is a good city water supply, a sprinkler system should not cost over $7,500 and the annual saving should be at least $2,000.

25. If the property owner does not care to use his own money for this purpose, there are several finance companies which will install the equipment, and the payments are spread over several years to conform to the savings in insurance. In other words, he buys his sprinkler system with the savings in insurance premiums and does not have to invest any ot his own capital.

26. The figures available on the fire loss in manufacturing and mercantile properties of the better class show a loss of about 3 cents on a hundred dollars of property value. It is a fair estimate that the fire loss on these same properties without sprinklers would have been from 10 to 20 times as great.

27. Automatic sprinkler systems do not always control fires. The failures, however, are not due to the sprinkler heads themselves, but to the lack of proper water supplies or to other reasons which do not in any way detract from the value of the protection with proper installation and maintenance. The twenty-seven year record of the National Fire Protection Association includes 28,817 fires in sprinklered plants, where heat was sufficient to operate the sprinklers. Of these fires, 19,007 were practically or entirely extinguished by the sprinklers, this being 66.0 per cent. of the total number. In 8,583 fires, or 29.7 per cent. of the cases, the sprinklers held the fire in check so that it was extinguished with the aid of other apparatus, such as hose streams. In 1,227 fires, or 4.3 per cent. of the total number, the fire was not properly controlled by the sprinklers.

28. A study of these unsuccessful sprinkler fires is of great importance, in that it shows how to guard against such occurrences. The following table briefly summarizes the probable causes to which the unsatisfactory work of the sprinklers may be attributed:

	Number	Per Cent.
Failure due to water being shut off............	360	29
Defective or partial equipment................	249	20
Faulty building construction and obstruction....	132	11
Inadequate or light water supply..............	111	9
Exposure or conflagration.....................	71	6
Hazard too severe for control as installed......	70	6
System or supplies crippled by explosion........	55	4
System crippled by freezing...................	41	3
Defective dry valve or dry system..............	33	3
Unsatisfactory action of high test heads........	22	2
Unaccounted for and miscellaneous.............	83	7
	1,227	100

29. Without going into these matters in detail, it will be noted that in most cases there is a satisfactory and reasonable explanation which in no way detracts from the efficiency of the automatic sprinkler system when properly installed and maintained.

30. The same fire record also shows that the number of fires extinguished by a small number of sprinklers is as follows:

No. of Sprinklers Operating	No. of Fires	Per Cent. of Total
1	9,281	33
2 or less	14,065	50
5 or less	20,144	72
10 or less	23,513	84
25 or less	26,134	93

31. This is a remarkable showing. Furthermore, when it is considered that in most cases where over ten or fifteen sprinklers operate it is due to defective equipment or water supply, the inevitable conclusion is that the probabilities of opening more than a few sprinklers under average conditions with a standard equipment is very slight. See Sprinkler Fire Record Tables beginning on page 743.

32. The fire record clearly emphasizes the soundness of the following essential principles of sprinkler protection:

a—Freedom from concealed places to which water from sprinklers cannot penetrate.
b—Location of sprinklers to cover all portions of premises.
c—Adequate piping system conforming to standard.
d—Automatic water supply sufficient in quantity and pressure and available at all times, preferably backed up by other supplies.
e—Systematic, thorough, and intelligent inspection and care of system.

ADDITIONS, EXTENSIONS, OR NEW BUILDINGS.

33. A very common cause for the so-called failure of sprinklers, is the addition or new building which is in use but has not been equipped with sprinklers. Many large losses on properties having sprinkler equipments have deen due to the fact that the fire started in a new portion which had not been equipped.

34. Sometimes these portions are not as hazardous as most or all of the rest of the property, and the property owner thinks the danger is slight, but he fails to realize the menace to the property as a whole; often the new portion is just as bad as the rest, but the owner delays in contracting for the sprinkler system. Even a relatively small addition or new building may be a severe menace particularly if there be a considerable amount of combustible contents. The heat from a fire in such an addition or building may spread rapidly through door or window openings and open a large number of sprinklers in a short time, thus overtaxing the sprinkler system or water supplies.

35. The property owner is not treating the insurance interests fairly, to say nothing of his own interest, in not extending the sprinkler equipment to such portions, as the insurance rate and premium is seldom properly or promptly adjusted to take care of such conditions. No matter what the construction, all such additions or new buildings should be equipped with sprinklers, and the system put in service, before the building is used for any purpose, and before combustible contents are introduced. If this fundamental rule had been observed, many large losses would have been avoided.

MAINTENANCE AND INSPECTION

36. Preceding pages call attention to certain defects which have brought about serious loss and which loss would in most cases have been avoided by frequent inspection and better maintenance.

37. Most sprinkler systems are inspected from time to time by insurance organizations. These insurance inspections vary in frequency and quality. Some organizations inspect three or four times a year while others may inspect once a year or less. It is difficult to obtain trained inspectors for this work. After all, the property owner himself is the one most interested in and benefited by his sprinkler system, and he should inspect his system frequently so that he may know for himself the exact condition of the system. (See Self Inspection, page 654.)

38. In many cases the property owner has no one in his employ who is competent to look after his system, in which case he has to largely rely on insurance or other outside inspections. Certain sprinkler companies maintain inspection departments which make examinations and reports of systems installed by these companies, and a number of skilled professional organizations are also available to the property owner who desires to maintain the best possible conditions.

39. Defects found by the inspectors of one of the large sprinkler companies during a period of four years are given in the following tabulation:

CLASS A

Vital Maintenance Defects which if not remedied, might result in the failure of the sprinkler system to properly control the fire

	Number of Cases Total to Dec. 1, 1922
Water shut-off sprinklers	627
Unsprinklered portions, etc.	11229
Defective water supplies	999
Sprinkler systems not properly protected from freezing	1306
Dry system not properly maintained	1417
High test heads used improperly, etc.	484
Obstruction to distribution	3663
Total Number Defects, Class A	19725
Total Number Defects, Class B	14562
Grand Total	34287

CLASS B

Less important defects which affect proper and economical maintenance or efficiency of sprinkler systems

	Number of Cases Total to Dec. 1, 1922
Insufficient supply of extra sprinklers on hand	185
Dry valve attachments missing	229
Alarm valves out of order or missing	224
Alarm attachments out of order	2215
Gate valves out of order	2192
Defective piping or supports	5124
Gravity tanks out of order	1628
Pressure tanks out of order	164
Fire pumps (Repairs needed)	60
Water supply defects	1741
Hose connections (In generally poor condition)	108
Outside sprinklers (Plugged heads, etc.)	92
Total Number Defects, Class B	14562

EFFICIENCY OF AUTOMATIC SPRINKLERS IN PLANTS OF VARIOUS OCCUPANCIES

40. Owing to the importance of the efficiency of automatic sprinklers in plants of various occupancies, the authors have reprinted on page 751, the National Fire Protection Association fire record of the Effect of Sprinklers by Classes of Occupancy, and have included extracts from this table in this section in order to show as clearly as possible the relative value of sprinklers in the more important lines of industry.

41. The question of modification of the Standard Sprinkler System where the occupancy seems to warrant either more or less than the standard is also involved, and the student of automatic sprinkler protection soon learns that while the average standard equipment is generally satisfactory for all plants, nevertheless in many cases the requirements are unduly severe to secure adequate protection, while in other cases additional protection is necessary to obtain the desired result. It is of course evident that where the building itself is of non-combustible construction, with a minimum of combustible contents, as, for instance, a machine shop, a relatively weak sprinkler system would be effective in extinguishing fires, whereas in a frame warehouse full of cotton or other combustibles the full standard is essential; and to go still further, in such plants as oil cloth drying buildings some special arrangement of sprinklers is necessary, owing to serious obstruction to distribution from stock.

42. The National Fire Protection Association records give sufficient data in many classes of property to admit of comparison. A selection from the tables of 1922 is as follows:

Industry.	No. of Fires.	Percentage of Fires Extinguished by Sprinklers.	Percentage of Unsatisfactory Fires.	Percentage of Unsatisfactory Fires Due to Defective Equipment.	Percentage of Unsatisfactory Fires Due to Hazard and Obstructions.
Boots and Shoes	704	73.3	3.5	1.1	.4
Celluloid	186	69.4	11.2	2.2	6·5
Clothing	893	81.5	.9	.1	.1
Cordage	309	65.1	3.5	1.6	.7
Cotton Mills	6111	62.0	1.1	.4	.06
Furniture	725	64.1	7.9	2.1	2.1
Grain Elevators	67	38.8	23.8	12.0	4.6
Knitting Mills	726	64.3	3.3	2.1	.1
Mercantile	955	80.1	1.9	.2	.0
Metal Workers	1133	65.1	4.1	1.4	.5
Oil Cloth and Linoleum	102	30.4	18.6	4.0	14.0
Paper	684	50.2	8.1	3.6	.4
Printing	651	80.6	2.6	.8	.2
Saw and Planing Mills	178	44.4	23.0	7.3	2.5
Woolen Mills	1249	70.6	4.6	2.3	.08

43. Commenting on this table, it is to be noted that the difference between fires extinguished and unsatisfactory fires represents fires held in check by the operation of sprinklers and extinguished by other agencies.

44. Generally, the higher the percentage of fires extinguished the lower the percentage of unsatisfactory fires, and vice versa.

45. The range of percentage of fires extinguished is from 81.5 per cent. in clothing factories to 30.4 per cent. in oilcloth and linoleum works, and the range of percentage of unsatisfactory fires is from 0.9 per cent. for clothing factories to 23.8 per cent. for grain elevators. This quite clearly shows the advisability of modifying the present standards to meet the needs of the class of occupancy and, of course, the construction.

46. Some light is thrown on the margin of safety by the percentage of unsatisfactory fires due directly to faulty or defective equipments. Where this percentage is small, as in mercantile risks, it would tend to show that a less powerful system than the average would give good results, while in knitting mills and furniture factories, for instance, the higher percentages tend to show a smaller factor of safety and the need of better equipment. Very powerful systems only are suitable for grain elevators and saw mills. This assumes that faulty equipments have existed in similar proportions in the various classes, which is not altogether true.

47. The column showing percentage of unsatisfactory fires caused by hazards and obstructions is interesting in comparing sprinkler control in the various classes. In several the record is practically perfect, while in celluloid and oil cloth factories the control is questionable.

48. The attempt to provide an equipment which will answer for all classes of occupancy and provide against all contingencies has led to the use of a standard with altogether too great a margin of safety and an expense of installation which is not warranted in the average property.

49. The Sypho Chemical Sprinkler System, described in Chapter 33, is designed to meet these sprinkler fire situations.

50. In most classes of risks the hazards of occupancy are not too severe for the average equipment, nor are the obstructions to distribution serious, and a study of the fire record shows comparatively few prominent classes where these particular features are likely to affect sprinkler control, such as celluloid works, cereal mills, cooperage, cordage works, cork factories, cotton warehouses, grain elevators, flour mills, furniture factories, match factories, oil cloth works, rubber works, saw mills, starch factories, varnish works, window shade factories, and woodworkers.

51. The important features of each class as affecting sprinkler control, with suggestions for increased protection or reduction of the hazard, are briefly enumerated.

CEREAL MILLS.

52. Dust explosions in this class of risk may cripple any sprinkler system. The working rooms can be ventilated to reduce the dust hazard. Storage bins when not full may have a serious dust hazard, and the danger of ignition can be minimized by screens and magnets at the attrition mills, as the chief hazard is sparks in the mills. Sprinklers have shown excellent results in cereal mills, but full standard equipments with water supplies above the average are essential and complete protection is vital, i. e., sprinklers inside of dust bins, chutes, conveyors, and all concealed spaces. See Flour Mills below.

COOPERAGE PLANTS.

53. Owing to the very serious obstruction to distribution from sprinklers, especially where barrels are piled several tiers high, fires sometimes get beyond control. The water supplies should have greater volume than is ordinarily needed and heavy pressure is also desirable. Barrels should preferably be stored in detached or cut-off buildings.

CORK FACTORIES.

54. Finely divided cork dust is particularly liable to explode and sometimes with sufficient violence to break the sprinkler pipes and cripple the system. This hazard can be largely overcome by means of blower and ventilating systems which will keep the room in which grinding is done sufficiently free from dust. It is also advisable to have the cork grinding processes in a building well detached from the main plant.

COTTON WAREHOUSES.

55. In a standard warehouse cotton bales are laid on end and never tiered. Where cotton is piled several bales deep, as is generally the case in non-standard warehouses, the obstruction to distribution of water from sprinklers is very considerable and fire is exceedingly difficult to extinguish. For such non-standard warehouses the water supplies should be well above the average as to volume and pressure.

FLOUR MILLS.

56. Except as regards construction, flour mills present similar problems to grain elevators. The dust hazard can undoubtedly be largely, if not entirely, eliminated by proper blower and ventilating systems and with this accomplished the flour mill presents no particularly severe hazards. Owing to the fact that the spread of fire is probably more rapid than in the average risk it is well to provide water supplies of larger capacity. As with cereal mills, it is of vital importance to have sprinklers inside all conveyors and enclosures.

FURNITURE FACTORIES.

57. The benzine varnish dip tank is perhaps the most severe hazard met with in these plants. Even with first class sprinkler protection the dip tank hazard should be safeguarded in every feasible way, otherwise a large number of sprinklers may open and overtax the system. The hazard should be isolated as much as possible from the rest of the plant, i. e., cut off in small room where a limited number of sprinklers will open. Additional safeguards can be provided such as automatic cover and overflow pipe. Methods of safeguarding dip tanks are covered in some detail in Chapter 7.

58. In most furniture factories there is a serious obstruction to distribution from finished goods in stock rooms and also from lumber, the latter particularly in dry kilns. Finished goods should be kept in a storehouse either separate or cut off from main plant. They should be piled as low as feasible and never within less than two or three feet from the ceiling.

59. A full standard equipment is particularly advisable in furniture factories and heavy pressure water supplies of large volume are desirable.

GRAIN ELEVATORS.

60. Severe explosions from grain dust sometimes occur sufficient at least partially to wreck the building and break the sprinkler pipes. While the dust hazard cannot be eliminated it can be greatly reduced by blower systems and proper care in frequently cleaning up the dust, especially around shafting and machinery where a fire is likely to start.

61. The construction of grain elevators is such that it is difficult to install an effective equipment and there are several unusual problems involved. Elevators settle and change their shape sufficiently to cause unusual strains in the sprinkler piping, making it difficult to maintain such a system in good condition. Furthermore a dry system must be used and the proper location and arrangement of dry valves is very important.

62. While it is true that there have been several so-called sprinkler failures in grain elevators, it is also a fact that in most, if not all, cases the sprinkler equipments have been faulty and there is no reason to believe that a standard equipment will not take care of a very large percentage of grain elevator fires. It is of the utmost importance that sprinklers be placed throughout all portions, such as elevator heads, legs, and boots, inside wooden machine enclosures, etc.

MATCH FACTORIES.

63. The mixing of match paste is extra hazardous and explosions are likely to occur. If the room in which this work is carried on has a standard cut-off from rest of plant the fire should be confined to that room and controlled without difficulty by the ordinary sprinkler system. The storage of chlorate is also important and this should be in a detached building.

64. In the work and packing rooms fires often occur, and while they spread somewhat rapidly they should be controlled by sprinklers without opening more than the average number of heads.

OILCLOTH WORKS.

65. Coating with benzine mixtures and drying constitute the chief hazards so far as sprinkler control is concerned. Where the drying is in rooms of considerable height and area, fires frequently get beyond control of the ordinary sprinkler system owing to the large amount of combustible material and the large number of heads opened. This has been the experience both with horizontal flat drying and with festoon drying methods. Such dry rooms require special treatment as regards sprinkler protection. Where the height of dry rooms is over 15 ft., side or aisle lines can advantageously be installed. They are particularly necessary with flat drying. The main supply pipes should be designed properly to feed all the sprinklers in the room when operating at the same time and this generally means water supplies of large capacity.

66. In small dry rooms or cells, such as are used in the manufacture of table oilcloth, it has been amply demonstrated that the ordinary sprinkler system will extinguish the fire without allowing it to spread to any extent.

PYROXYLIN PLASTIC (CELLULOID) WORKERS AND MANUFACTURING.

67. The great danger is from celluloid in bulk, either sheets or scrap. A standard equipment should control any fire except for stock in bulk, and the natural answer is, therefore, to store all stock or scrap in detached fireproof vaults, with only a small amount in any one section. A fire in bulk stock of celluloid is practically uncontrollable and explosions are likely to result; while if scattered in moderate quantities, as in the ordinary celluloid working establishment, celluloid fires are readily controlled by sprinklers. Under certain conditions, as in portions of plants manufacturing smokeless powder, both powerful automatic and open sprinkler systems have been installed.

RUBBER WORKS.

68. While large quantities of naphtha are used in most rubber factories, the only hazards which would probably affect sprinkler control are rubber cloth coating and drying and other large dry rooms such as are sometimes found in boot and shoe factories. These dry rooms become filled with naphtha vapor and quick flash fires result, opening all the sprinklers in the dry rooms and sometimes many in the rooms adjoining.

69. Full standard equipments are essential where these hazards exist, but as such fires are usually extinguished quickly the ordinary water supplies should be amply sufficient.

SAW MILLS.

70. The construction of many saw mills is such that large numbers of sprinklers are likely to open and overtax any available water supplies. Very high studded ceilings and open ends carry the heat away from the sprinklers directly over the fire and in buildings of such construction this cannot well be avoided.

71. The sprinklers must be designed to give good distribution from a large number of heads, with large feed mains and short branches. Only a small number of sprinklers should be allowed on one dry valve, say not over 150, and dry valves should be located as near as possible to the sprinklers which they control. Water supplies should be of sufficient volume to feed seventy-five or one hundred sprinklers at a time, and experience has shown that in many cases the water supplies were totally inadequate for saw mill building fires.

72. Obstructions to distribution are numerous and great care should be given to the proper arrangement and location of sprinkler heads.

STARCH FACTORIES.

73. Serious dust explosions have occurred in risks of this character, sufficient to cripple the sprinkler system. This hazard can be minimized by proper blower systems. The remarks made under flour mills also apply.

VARNISH WORKS.

74. Fires in open tanks of varnish, once started, are almost impossible to extinguish with water. Arrangements for draining such tanks can be made and covers (preferably automatic) provided.

75. Where rooms are not too large and there is plenty of boiler capacity live steam can be used to advantage. The storage of varnish in bulk should be in a separate building.

76. Even with good sized open tanks the water from sprinklers is of great value in helping to hold fire in check and the water seems to have a smothering effect. Such a fire will, however, burn much longer than the ordinary fire and in all risks of this class the sprinkler system should be full standard and have water supplies of large volume.

WINDOW SHADE FACTORIES.

77. The ordinary festoon drying of cloth coated with naphtha cut paint or varnish, presents a serious hazard both as regards the rapid spread of fire and obstruction to distribution. In this class of risk the sprinkler system should be full standard and if rooms are of large area particular attention should be given to the arrangement of the risers and feed mains. Water supplies should be above the average, both as regards volume and pressure.

WOODWORKERS (rough, not finishing).

78. In this very large class of risks there are three main features affecting sprinkler control: Sawdust vaults, lumber dry kilns, and obstruction to distribution from stock.

79. In the lumber dry kiln we not only have obstruction to distribution from the lumber itself but also frequently a blower system which aids in the spread of fire. With such a blower system arrangements should be made for quickly shutting down the blower, both automatically and manually. The dry kilns should be of small area and the lumber should not be piled close to the sides of kiln, nor should it be piled within two or three feet of ceiling. Sprinklers should be spaced somewhat closer together in dry kilns so as to give an extra amount of water, and as such fires are particularly difficult to extinguish the water supplies should be of ample volume. Doors should be kept closed in case of fire so steam from water of sprinklers can smother fire.

80. Explosions have frequently occurred in sawdust vaults, and side walls should be heavily constructed, with positive cut-offs from other buildings. Any fire in a sawdust vault can be entirely isolated regardless of sprinklers. See page 63.

81. Owing to the fact that obstructions to distribution from stock are more severe in woodworkers than in many other classes of risks, the sprinkler system should be full standard, with water supplies above the average, both as regards volume and pressure.

SPECIAL OR MODIFIED SYSTEMS

82. The foregoing pages have called attention to a number of properties where the fire hazard is unusual or of more than average severity. There are a large number of properties where the fire hazard is much less than the average as, for instance, dwellings, apartment houses, hotels, churches, hospitals, institutions, public buildings, schools, colleges, office buildings, etc. Small stores or mercantiles are much less hazardous than most manufacturing properties.

83. While, therefore, the full standard sprinkler system or even a "super" system may be necessary for some hazardous classes of property, a system less powerful than the standard may be ample for properties where the fire hazard is relatively light. There is only one standard under the rules and this is required in all cases. This standard is designed properly to protect all classes of property including hazardous manufacturing properties.

84. It is generally agreed that from the standpoint of good fire protection, the same powerful system required for a cotton mill is not necessary in these light hazard properties, but so far no other standard or modified system has been adopted.

85. The Grinnell Co. Inc., developed a so-called Special System for schools, hospitals, etc., and a number of these systems were installed. This system provided for 2½- to 3-inch feeders as a maximum, and the sprinklers under smooth ceiling were spaced further apart. This system would properly feed from 12 to 15 sprinklers and it is not expected that more than this number of sprinklers would be called upon in these classes of property. The cost of such a Special System would average 25 per cent. to 40 per cent. less than the National Standard System.

86. In some localities the insurance interests permit the use of three-inch feeders as a maximum in certain classes of property. The attempt to provide an equipment which will answer for all classes of occupancy and also provide against all contingencies, has led to the use of a standard with too great a margin of safety and an expense of installation which is not warranted in the average property.

PARTIAL SYSTEMS

87. In most properties used for manufacturing or mercantile purposes the fire hazard is more or less equally distributed throughout the property and a complete sprinkler system is essential. This, however, is not equally true of some classes of property where a considerable portion is used for dwelling, office, or assembly purposes where the danger of fire is slight, while in other portions the danger of fire is much greater, and if a fire does start, it may spread rapidly before it is discovered.

88. The properties mentioned under Special Systems (par. 82) are of this general type and include buildings used in part for dwelling or office purposes with the basement and first floor used for mercantile or similar hazard occupancy. It happens that many of these properties are especially important from the standpoint of safety to life as people may live or congregate in large numbers in such buildings. There has been a serious loss of life in a number of schools, hotels, institutions, etc. and in most cases the fire has started in the basement or working portion, or, if starting in the living or assembly rooms, the fire spread rapidly because of open halls, stairways, or elevators.

89. Because of the relatively low insurance rates and the small property value, the saving in insurance for a complete sprinkler equipment is much less with such properties than for manufacturing or mercantile properties of the same size, and the cost of a complete standard system is often considered prohibitive when compared to the saving in insurance or the protection afforded.

90. It is, therefore, proper to consider the value of a partial sprinkler system for many such properties, that is, to equip with sprinklers those portions not used for living, assembly, office or similar purposes, and which would generally include basements, working portions (such as kitchens, laundry, boiler rooms, etc.), storerooms, attics, hallways, stairways, elevators, chutes, etc. Statistics for such classes as schools, colleges, hospitals, institutions, and hotels seem to show that well over half of all fires start in the basement or working portions and also that fires starting in these portions are more likely to spread rapidly than fires starting in small rooms.

91. It seems fair to assume that if these portions of such properties are equipped with sprinklers, the danger of serious fire will be reduced at least two thirds and the danger to life even more than that, for the sprinklers in hallways and floor openings will do much to prevent the rapid spread of fire even though the fire may start in portions not equipped with sprinklers. The cost of such partial equipments is of course far less than a complete system, and if the insurance cost were reduced in proportion to the protection afforded, and the property owner realized the materially reduced danger to life, a large number of such partial systems would be installed.

92. Analysis of Where Fires Start in Schools, Institutions, and Hotels—(Taken from the N. F. P. A. Quarterly of January, 1921.)

Location of Start of Fire.	Schools and Colleges.		Institutions.		Hotels.	
	No. of Fires.	Percentage of known Fires.	No. of Fires.	Percentage of known Fires.	No. of Fires.	Percentage of known Fires.
1. Basement	21	28	4	14	28	18
2. Working portions (excl. bsmt.)	25	33	14	48	75	47
1 and 2 together	46	61	18	62	103	65
3. Roof or exposure	8	11	2	7	15	9
4. Elsewhere	20	27	9	31	43	27
5. Total Known	74		29		161	
6. Unknown	16		6		14	

BASEMENT SPRINKLERS.

93. As set forth in the preceding section, basements, especially in certain classes of occupancy, are particularly hazardous in comparison with other portions, and hence automatic sprinklers are of great value, even if installed only in basements and sub-basements.

94. The fighting of fire in basements is generally so difficult or dangerous that this is an additional argument for sprinklers.

95. In some cities the authorities have required some form of special protection for certain basements, such as perforated pipes, open sprinklers, and automatic sprinklers. The latter is of course far more efficient than any system which is hand operated, and a complete system of automatic sprinklers throughout a basement is of considerable value. The water damage in case of fire is far less when automatic sprinklers are installed than when the entire basement is flooded by means of perforated pipes or open sprinklers.

96. Where such basement equipments have been installed there has generally been insufficient attention paid to standards for pipe sizes and spacing of heads, so that many such equipments are of doubtful value.

97. Whenever automatic sprinklers are installed in a basement, the work should be done in conformity with the standards for automatic sprinkler protection, and it is always advisable to provide connections and feed mains of sufficient size and so arranged as to permit the extending of equipment to upper floors if desired.

SUPERVISION AND CARE OF VALVES

98. The sprinkler fire record shows that about 5 per cent. of all the fires reported are failures in that the automatic sprinklers do not hold the fire in check. Of this 5 per cent. about one fourth are due to closed gate valves, or, in other words, about one and one fourth per cent. of all the fires reported are not controlled because the water is shut off at the time of fire.

99. Inspections by the insurance interests also show many closed valves, and the question of supervision for sprinkler valves is the most important single maintenance item in connection with the sprinkler system.

100. The importance of keeping sprinkler valves open was, of course, understood even in the early days of sprinkler protection, but it required a number of serious fires due to closed gate valves before any earnest consideration was given to this danger.

101. The following table is taken from the 1922 Annual Report of the N. F. P. A., giving classification of Fires, etc.

	1897–1922 No. of Fires
Water shut off for unknown reason, neglect or carelessness...	134
Water shut off to prevent freezing..........................	73
Water shut off due to accidents or repairs..................	60
Water shut off before fire was out, or fire rekindled..........	54
Water shut off, miscellaneous..............................	15
Water shut off, leaky dry system...........................	11
Water shut off, probably incendiary.........................	6
Water shut off, defective gate valve.........................	7
Total	360

102. The National Board Rules classify the various methods of supervising valves in the order of their efficiency and importance:

1. Central Station Supervisory Service.
2. Local Automatic Valve Notification.
3. Local Non-Automatic Valve Recording Systems.
4. Valve Sealing Systems.

CENTRAL STATION SUPERVISORY SERVICE.

103. This is an automatic signal system and a fire protection follow up service which is designed to increase the efficiency of automatic sprinkler systems. The signal apparatus itself must be properly designed and installed to meet severe operating conditions, but of even greater importance is the prompt receipt of the warning signal and the action taken. Sprinkler systems are effective, because they attack the fire where it starts and when it starts, and, similarly, Central Office supervision is effective, because it gives prompt notice to the proper party and indicates what has happened.

104. The principal object of Supervisory Service is to insure the continuity of sprinkler protection, and Central Offices have been established in practically all cities of over 100,000 inhabitants, which are in charge of competent employees and have constant electrical supervision over all the important elements of any sprinkler system.

105 The automatic signal system installed in the sprinklered property transmits telegraphic signals upon operation of the system or derangement from normal, and the information thus received by the Central Office is transmitted to those who are most interested, namely, the property owner or the city fire department. The Supervisory Service signal system is entirely automatic in its action, the signals being initiated by changes in the sprinkler equipment itself and in turn automatically transmitting distinctive signals to the Central Office operators. The devices in general are all provided with tamper signals so that they cannot be disconnected or disturbed without automatically transmitting trouble signals. The points covered by Supervisory are as follows:

106. Supplies-Tanks-Pump-City Connection—Signal actuating devices are attached to the various sources of supply which will initiate signals as conditions of these supplies change from time to time. In gravity tanks, pressure tanks, surge tanks, reservoirs, etc., a water level float is installed at the proper water line, which actuates a transmitter, and telegraphs a signal to the Central Office, showing water level is too high or too low. In case of city water, pressure tanks, etc., automatic pressure actuated gauges are installed and set to operate within given limits, thus giving warning where pressure conditions are not constantly maintained. Where any of these sources of supply are subject to freezing, additional devices for signaling are installed, which give notice before water in supply reaches the freezing point, thus preventing frozen tanks and consequent damage to supply.

107. Gate Valves—All gate valves which control the supply of water from the tank or other source of supply to the sprinkler head, are protected with mechanical-electrical signaling attachments which indicate when the gate valve is closed or open, thus keeping a constant automatic check on conditions of these valves.

108. Air on Dry System—Air pressure on dry system is supervised by means of a special pressure actuated electric attachment, which initiates signals whenever the pressure varies from the limits permissible for the particular dry valve supervised, thus avoiding the unnecessary tripping of the dry valve.

109. Water Flow—At the base of each system riser especially designed electrical signaling attachments are installed which operate by a flow of water through the valve. These give prompt indication of the passage of water whether due to leakage or fire. Special arrangements have been provided in the transmitter for this particular service which retards the alarm sufficiently to prevent false signals from water hammer and local conditions of similar nature. At night time these signals are at once transmitted to the fire insurance patrol and fire department.

110. Manuals—Break glass manual fire alarm boxes are generally installed at various points, so that the fire department can be promptly called when necessary.

111. Handling of Signals—Upon receipt of signals referring to maintenance only, as for instance, a closed gate valve, low water signals, low pressure, etc., the operator at the Central Office gets in immediate touch with the owner or his representative and explains the trouble that has developed with the equipment.

He also promptly sends a runner to the premises with written notice as to the nature of the trouble. He also records these signals in a log book and makes a daily report to the insurance interest having jurisdiction. In this manner, all faults of maintenance are promptly brought to the attention of the parties who are most interested so that they may take the steps necessary to restore the protection at once. Further, during nights, Sundays, and holidays, upon receipt of signals indicating fire or water flow, notice is promptly given to the city fire department or patrol.

112. Record—Sprinkler Supervisory Service has been in effect some twenty years. At the present time there are something over three thousand sprinklered plants under protection and the record of signals received from these equipments for 1922, showed 77,321 abnormal conditions developed during that year in these properties. This is an average of about one signal in every two weeks for each equipment. Further, it is a well-known fact that the mere installation of Sprinkler Supervisory Service itself tends to cut down the number of unsatisfactory conditions. This is accounted for by the fact that those in charge of maintaining a sprinkler equipment do not care to have such minor details brought to the attention of their superior officers and consequently take additional precautions to keep the equipment in first-class order so that no signals will be transmitted. The records of losses in supervised sprinklered equipments, indicate a surprisingly low loss ratio for 1922, being something like $0.052 per hundred dollars of value carried.

113. The cost of Sprinkler Supervisory Service varies with the sprinkler equipment, the two principal factors being the expense of installing Supervisory Service apparatus in a given property and the expense of wire rental in connecting same to the Central Office. In general, this charge will average about one half to one third that which would be needed for watchmen.

LOCAL AUTOMATIC VALVE NOTIFICATION.

114. This includes systems where the operation of a valve produces some form of signal and a record at a common point by electrically operated devices and circuits continually under test and operating through an approved local central station, all in compliance with the standard regulations for the installation, maintenance, and use of signaling systems so far as they may apply.

LOCAL NON-AUTOMATIC VALVE RECORDING SYSTEMS.

115. In this class are included all appliances attached to or connected to valves for the purpose of making a permanent record of the condition of the valve continuously or at times when inspections are made for this purpose. Their object is to procure a truthful record of the condition of the valves and to encourage frequent visits to the valves by those having them in charge, to further their familiarity with the valves' location, their purposes, to prevent unauthorized operation of the valves, and to insure their ready accessibility. The rules for this class provide for a device at the valve and means by which a record is made by the watchman or whoever visits the valve and this dial or card record is then approved and filed by the person responsible for the condition of the system.

116. The Newman Valve Supervisory Devices are the only ones which to date have qualified under this class. Mechanical devices are attached to gate valves, including indicator posts, a watchman's clock key is provided, and the device so designed that the key cannot be used for making a record unless the valve is open.

117. The most important times of day to make the record are just after plant or building starts up for the day and just before closing time. The latter is important in that if a valve is found closed persons in authority can be notified before they leave and valve opened or necessary precautions taken.

VALVE SEALING SYSTEMS.

118. This class covers the standard method of sealing and tagging valves with the object of preventing so far as possible their unnecessary closing, to obtain notification of such closing, and to aid in restoring the valves to normal conditions. Some insurance organizations make use of seals and tags and require the property owner to notify them at once in case a valve is closed or seal broken. The insurance inspector attaches the wire and lead seal. When a seal is broken it is advisable for the property owner to use a strap and padlock until such time as the insurance seal is replaced. With seals or any other form of fastening valve there should be sufficient slack for the valve to be operated one full turn without breaking the seal.

119. Where tags are used they should state the apparatus controlled by the valve, number of the valve, the date sealed, name of person sealing valve, and instructions for use in case the seal is broken. An index board can be used to advantage by the one in charge of sprinkler system, and when a valve is closed a notification tag is hung on the board until valve is again opened.

120. Leather Straps and Padlocks—The Sprinkler Rules formerly provided that valve (unless sealed) be fastened open by means of a leather strap and padlock and this method has been very generally used for many years. A relatively light strap about one half inch wide of leather or some tough woven material, with an enameled iron ring, riveted to each end, and a cheap but durable brass padlock is recommended. The padlocks can all have a common key with one key in the office, another with the watchman and another with the one in charge of system. In case of emergency the strap can be broken or cut. This method is easily available to any property owner and a tag system can be used as a further precaution.

121. Daily or Weekly Inspection—In many large plants a daily inspection is made of all valves and a signed report turned in for evidence as to the condition of valves. Such inspection should be made at least once a week in all cases. The valve should be given a part turn to see that it operates properly and the valve report should state that the valve is open and strapped or sealed. See also Chapter 37.

122. Indicator Post Gate Valves—Indicator post gate valves in yards can generally be treated in similar manner to inside gate valves. They should be provided with locking bars so that they can easily be strapped or sealed. Such valves can be included in a tag system.

SPRINKLER LEAKAGE

123. The automatic sprinkler system consists of piping, sprinklers, and other apparatus, all subject to the strain of water under pressure and the constant danger of accidental water discharge or leakage.

124. It has been roughly estimated that 50 per cent. of the property losses from leakage are due to the sprinkler head, chiefly on account of external mechanical injury or freezing. Thirty per cent come from the ordinary piping or fittings, and 20 per cent from the collapse of tanks or rupture of main supply pipes

125. Over a period of five years, the experience of companies specializing in insuring plants under sprinkler protection has shown the likelihood of sprinkler heads opening from causes other than fire to be from 1 in 35,000 to 1 in 60,000 per year. The records of an important sprinkler installing company show an experience of 1 in 140,000 per year.

126. Some of the more important undesirable conditions as affecting sprinkler leakage and water loss are as follows:

a—Wooden tanks having flat hoops, and located near or over buildings.

b—Heavy vertical piping supported by an elbow with no footing under the elbow.

c—Individual sprinklers so located as to be easily subject to mechanical injury

d—Lack of sufficient heat in cellars, closed attics, shipping sheds, and entry ways.

e—Unsupported lead joints subject to direct water hammer.

f—No watchman service or satisfactory sprinkler alarm, so that water may flow for considerable length of time before being discovered.

127 The Automatic Sprinkler—The sprinkler head is designed to stand at least 300 pounds pressure without injury or leakage. Sprinklers are constructed and manufactured under unusually good shop conditions, and if carefully and properly installed there is little or no danger of leakage at the sprinkler head unless it is injured in some way. Sometimes the sprinkler is injured when being screwed into the pipe or not properly screwed in, but such instances are extremely rare.

128 There is probably not much difference between the modern approved sprinklers as regards their strength or liability to injury They will stand rather hard usage without leaking and the frames can be bent without breaking. While many cases of water damage from sprinklers are due to mechanical injury, it is generally on account of unusual conditions or gross carelessness.

129 Where the sprinkler is located so as to be easily subject to mechanical injury, it is desirable to provide metal guards to protect it. Such guards can be secured from the sprinkler companies.

130. The danger of the modern approved sprinkler breaking apart without being injured in some way, even under extra heavy pressure such as 150 pounds, is extremely remote. Shop practice has been improved, the sprinklers are all carefully tested, and the manufacture of approved sprinkler heads is under the constant supervision of the Underwriters' Laboratories.

131. Piping and Valves—The causes of leakage are chiefly the following:

a—Defective piping or fittings, as, for example, too thin or having sand holes.
b—Defective workmanship when installing system, as, for example, undue strain caused by piping not being the right length.
c—Heavy piping not properly supported.
d—Insufficient fastenings when cast and wrought iron piping come together.
e—Freezing.
f—The settling of a building or change in floor level putting severe strains on the heavy pipe.

132. Freezing—Freezing is a common cause of water leakage and difficult wholly to guard against in northern climates where the temperature frequently drops to far below freezing and sometimes without much warning. The best of care and supervision is practically the only remedy in closed attics, hallways, dormer windows, basements, or other places where there is danger of freezing. A thermometer which registers the minimum temperature can be used to advantage. The practice of insulating or wrapping the pipe up to and around the base of the sprinkler is merely a makeshift and usually not to be relied upon. Sometimes steam piping can be run alongside the sprinkler piping and both insulated with noncombustible material.

133. Where it is not feasible properly to heat the premises, the air or dry system should be used. Such a system very closely approaches the ordinary wet system in efficiency, and it is far better to use a dry system than to take chances of frequent freeze-ups and interruptions to sprinkler service.

134. Gravity Tanks—There have been a number of serious accidents due to the collapse of gravity tanks or the structures supporting them. The causes are various and include:

a—Weak or defective foundations.

b—Weak walls for supports.

c—Poorly designed or weak trestles or supporting structure. See Fig. 53, page 376.

d—Breaking of tank hoops due to corrosion.

135. The latter is perhaps one of the more common causes, and the old style thin flat hoop is pretty sure to give trouble sooner or later as it corrodes on the inside and loses its strength. Only round hoops should be used and these should be painted frequently.

136. Not only severe property damage, but also loss of life has been caused by the collapse of gravity tanks. The work of erecting gravity tanks should only be entrusted to reputable and experienced concerns.

137. Sprinkler Alarm Valves—Sprinkler alarms are not only valuable on account of giving prompt notice of the operation of the sprinkler at times of fire, but also in case of water leakage or discharge from causes other than fire. For this reason alone every sprinkler system should have alarm valve protection.

138. There are several types of alarm valves, and they all require some degree of supervision and more or less frequent tests. See Chapter 31. Some are designed to make an electric connection only and others have also a rotary gong attachment. Open circuits are often employed, and the circuit and bells should be tested daily. The water driven rotary gongs are subject to clogging or disarrangement from ice, snow, birds' nests, etc., but usually give fair service.

139. The alarm valve is supposed to operate with the opening of a single sprinkler head, and the only proper test is to draw water from the sprinkler system under the same conditions. This requires a ½-inch outlet at or near the top of the system or a smaller outlet, say ⅜-inch, if near the alarm valve.

140. The central station supervisory service in connection with alarm valves undoubtedly gives the best results.

141. Shut-off Valves—The need of shutting off water promptly in case of accident is self evident. From a fire standpoint, the fewer the valves, the less is the danger of valves being closed, and modern practice tends towards the elimination of all unnecessary valves. With high buildings, large floor areas, and damageable stock, it is undoubtedly advisable to have inside valves, and the condition of these valves can be properly safeguarded by supervisory service or frequent inspection.

142. All valves should be easily accessible and they should be clearly marked to designate the portion of the building which they control.

SPRINKLER LEAKAGE REPORTS.

143. The insurance companies have adopted a standard form of inspection report for sprinkler leakage with the following principal topics:

144. Occupancy—Class of goods; how piled; properly skidded; value in basement.

145. Construction—Height of building; type of floors; water proofing of floors; floors arranged to drain.

146. Alarm Service—Watchman; sprinkler alarm; sprinkler supervisory service.

147. Sprinkler System—Water supplies; static pressure increased by direct pumping; wet or dry system; type of sprinklers; piping and sprinklers when installed.

148. Gate Valves—Where located; readily accessible; drip valves.

149. Gravity Tank—Size; where located; age; how supported; condition of tank and hoops; expansion joints; tank and feed pipe protected from freezing.

150. Liability to Breakage—Poor supports; corrosion; stock piled around sprinklers; defective sprinklers; sprinkler head guarded where necessary; especially liable to mechanical injury.

151. Liability to Freezing—All rooms properly heated; blind attics or concealed places; main feed pipe and risers properly protected; dry valve closets heated; any sprinklers shut off in winter.

CORROSION OF AUTOMATIC SPRINKLERS

152. It is very important that the limitations of sprinklers be recognized quite as well as their great value. Sprinklers generally have no place in buildings where there are serious corrosion or loading hazards. The following illustrations show what can happen to approved sprinkler heads under such conditions. Proper construction and sub-division and control of hazards is the method of treatment that should be adopted in cases where corrosion and loading danger is serious.

153. The following applies to the solder release type of sprinkler. See also page 501 for description of Bulb type of sprinkler.

METHODS OF PREVENTING CORROSION.

154. Corrosion may affect the solder or the moving parts so that they will not operate as designed. This can usually be detected by a surface examination and in all cases where the metal or solder is not smooth or bright, sprinkler heads should be removed and thoroughly tested. The frequent inspections by the insurance interests make it generally feasible to leave this question to the inspector, allowing him to remove heads to test as he may deem necessary.

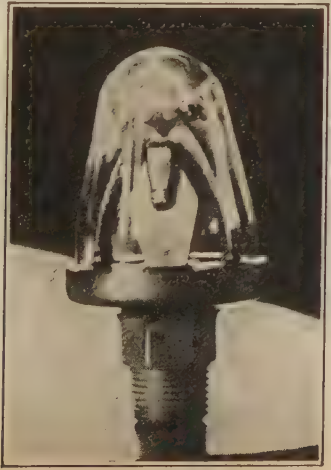


Fig. 74. Glass Cap Protection for Grinnell Head.

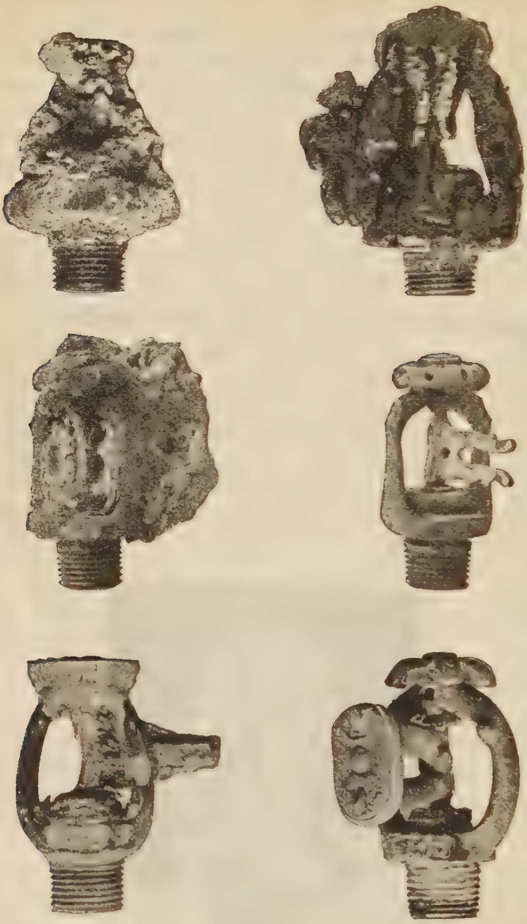


FIG. 75. EXAMPLES OF CORRODED AND LOADED AUTOMATIC SPRINKLER HEADS.

155. Heads suspected of being dangerously corroded or loaded should be tested to determine their actual condition. Under an arrangement with the manufacturers of sprinklers, the Underwriters' Laboratories test, without cost to owners, any heads that are sent in for examination. Twelve sprinkler heads are generally desired. Comprehensive test reports and opinions are rendered by the Laboratories.

156. Various methods have been tried for preventing the corrosion of automatic sprinkler heads; most of these being in the form of a coating, such as paraffine, asphaltum, or wax, and while some of these are unqualified failures, several of the prominent sprinkler companies are installing, where necessary, wax-coated heads which give fair satisfaction unless the conditions are more than ordinarily severe. The wax melts at a lower temperature than the solder, so that it should not affect the sensitiveness. Lead coatings have been used, but the protection afforded is generally slight. The use of glass caps on Grinnell heads gives considerable protection against corrosion and loading, providing the cap is sealed in the groove in which it rests, and provided, of course, these fairly thin caps are kept intact. They slow up the action of the sprinkler head about one temperature classification; for example, a 155° head operates about as readily under a cap as a 212° head in the open. See Fig. 74. Where the corrosive influences are severe, as in some parts of bleacheries, paper mills, chemical works, etc., the sprinklers may have to be changed frequently and new coated heads installed.

FIELD TESTS.

157. The Western Factory Insurance Association issued the following corrosion test instructions:

158. Our ordinary corrosion tests are Nos. 1 and 2, as below. Test sprinklers exposed to corrosive influences by any or all of the following tests:

First—Test any portion of the exposed fusible solder by applying the point of a knife like a chisel. Note whether the solder will curl or twist as a chip. If the solder is brittle or crumbles and will not curl, the sprinklers have failed to pass the test.

Second—Plunge the sprinkler into hot fluid approximately 50 degrees hotter than the theoretical fusing point of the sprinkler. Note if the sprinkler opens satisfactorily within 30 seconds.

Third—Test sample sprinklers in this field in a japan oven, dry kiln or other factory hot box, allowing time at discretion and 50 degrees higher temperature than the theoretical fusing point of the heads. Note if sprinkler fuses properly.

Failure to pass any of the above tests may be taken as sufficient ground for requiring renewal of the sprinklers.

For ordinary sprinklers No. 2 test does not require a thermometer, because boiling water is 50 degrees hotter than a 162 degree head.

159. It must be borne in mind that corrosion sometimes seriously affects solder, although the head may show very little injury. In other cases, the head may look very badly, but not be much injured.

LOADING.

160. Closely allied to corrosion is loading of sprinkler heads with materials such as paper pulp, drying oils, fibers, and dusts. Materials which harden when they absorb water are particularly to be feared. See Fig. 75. Loaded heads must be cleaned or replaced.

HIGH DEGREE OR HARD SPRINKLERS

161. In the ordinary, or low test, sprinklers, a fusible solder is used which melts at approximately 160°. This solder is composed of: Tin, 12 per cent.; lead, 25 per cent.; bismuth, 50 per cent.; cadmium, 13 per cent. The sprinkler companies are required also to furnish high test heads, which will operate at approximately 212°, 286°, and 360°, making in all four types, so far as melting point is concerned.

162. These so-called "high test" sprinklers should be marked with a distinctive color and new approved heads are so marked. An enamel paint is generally used, the ordinary or "low test" sprinklers not being painted.

163. Intermediate degree heads are painted white, are marked 212°, and are required to fuse between 200° and 225° Fahr.

164. Hard degree heads are painted blue, are marked 275°, 280°, 286°, and 300°, respectively, and are required to fuse between 275° and 300° Fahr.

165. Extra hard heads are painted red, are marked 360°, and are required to fuse between 360° and 400° Fahr.

166. It is evident that the use of these high test heads is essential in some locations, such as dry rooms, boiler rooms, etc., and it is found that there is some danger of the low test sprinkler operating if located in the top of skylights, near steam pipes, or in other places where the temperature may be 30 deg. or 40 deg. above the normal. One rule provides that low test heads shall not be nearer than 30 inches above or 12 inches to one side of steam pipes. In some cases the high test head has been installed where it was not necessary and the protection thereby impaired. Furthermore, some of the older types of high test heads have been thoroughly unreliable as to their operating temperature and there have been several cases of failure of such heads.

167. If the temperature exceeds 110 deg., the 212 deg. sprinkler should be used. Similarly it is desirable to allow a margin of about 50 deg. for the other high test heads, i.e., use 285 deg. heads if temperature exceeds 235 deg., and 360 deg. heads if temperature exceeds 310 deg.

168. The Grinnell Silica Bulb Sprinkler is set at 135 deg. for the regular or low test head. The high test heads of this type will be relatively lower in operating point than the solder type sprinkler.

FIELD TESTS AND INSPECTIONS

169. The National Fire Protection Association has published a manual on Field Practice which contains information and suggestions with reference to the proper maintenance and care of fire protection apparatus and devices, including automatic sprinklers. Some of the more important points are included here as being of interest.

AUTOMATIC SPRINKLERS.

170. When installed? Type? Approved? Corroded? Dirty or clogged? Clear space of 24 inches below level of sprinklers? Any portion not equipped with sprinklers such as closets, under benches, under stairs, etc.? Any changes in partitions or construction which would require more sprinklers or relocating the sprinklers? Any high degree sprinklers and if so where located?

171. A supply of not less than six extra sprinklers of each temperature should be kept on hand, so that heads which are operated by fire or broken or damaged can immediately be replaced. If any sprinklers show signs of corrosion or if condition is otherwise questionable, samples should be removed and sent to the Underwriters' Laboratories, who will test them free of charge; ordinarily one dozen samples are desired. Sprinklers which have been painted, varnished, or otherwise changed from their original condition should be replaced with new sprinklers. This does not of course apply to sprinklers which have been coated to resist corrosion.

SPRINKLER PIPING, FEED MAINS, AND RISERS.

172. Is piping properly protected against mechanical injury? Is it used for support of clothing or goods of any kind? Badly corroded?

173. Piping should be securely supported. Building vibrations are liable to loosen supports. Serious water damage may follow a broken pipe or feed main.

GATE VALVES.

174. See page 483 for methods of preventing gate valves from being shut at times of fire outbreak. Are all gate valves labeled so as to designate what they control? Are they easily accessible? Clean? Oiled and easily operated? Strapped or sealed? Post indicator provided with wrenches? Are valves in pits well cared for and accessible?

175. It is advisable completely to close and open all gate valves at least once a year so as to determine whether they are in operating conditions, and the valve stems should be oiled at the same time. Frequent tests are objectionable, in that there is greater danger of leakage at stuffing box. All valves including those underground should be plainly marked as to the direction in which they close.

ALARM VALVES AND DRY VALVES.

See Chapters 31 and 32.

WATER FLOW TESTS.

176. The efficiency of any water supply is determined by its ability to discharge a satisfactory volume of water under adequate pressure conditions.

177. The normal or static pressure should be determined by means of pressure gages permanently connected to top of riser and at bottom of riser above and below the alarm valve, dry valve, or gate valve, or on feed main at entrance to building.

178. The pressures on these gages should frequently be recorded so that maximum and minimum as well as average conditions may be determined.

179. The test pipe at top of system, when opened wide, should have little or no effect on the pressure at top of riser when the gage is attached directly to riser and not to test pipe.

180. With gravity tank or private reservoir as a primary and automatic supply, the gage at top of riser should show a static pressure equivalent to height of water level above this point, assuming no drafting of water, and this pressure should be approximately maintained with test pipe open. It is possible, however, for pressure to be increased in system by water hammer or temporary excess pressure, and so maintained or "bottled up," in which case there may be a material decrease in pressure when test pipe is opened, which lessened pressure will generally remain after test pipe is closed

181. A minimum flowing pressure of 15 pounds at top of riser is considered satisfactory for good protection but 25 pounds is better This means that water level in tank or reservoir is not less than about 60 ft. above the top of riser. It is assumed that the top of riser is within two or three ft. of the level of top line sprinklers, otherwise these pressures should increase accordingly, having in mind that one pound is the equivalent of a difference in elevation of 2.3 ft.

182. The standard ½-inch test pipe gives a relatively small flow (about equal to one sprinkler) and it is evident that a gate valve may be nearly closed or feed mains badly clogged and still have relatively little effect on flowing pressure with this small volume flowing.

183. The two-inch drip pipe at base of riser or at alarm valve or dry valve is the simplest method for a satisfactory water flow test. The normal or static pressure at this point having been noted, and any excess pressure removed by opening and closing the drip, it is possible to compare the static pressure with the flowing pressure when the two-inch drip valve is opened wide.

The pressure gage should be attached directly to the riser, not to the drip pipe.

184. The minimum advisable static pressure at the base of the riser, with all excess pressure removed, is about as follows:

1-story building	35 pounds.
3-story building	45 pounds.
5-story building	60 pounds.

185. This applies to water works or reservoir systems with large volume. Gravity tanks may give slightly less pressure and still be considered satisfactory, there being less or no danger of reducing the pressure materially at time of fire owing to hose streams or fire department using tank water.

186. The minimum advisable flowing pressure with two-inch drip pipe open is about as follows:

1-story building	25–30 pounds.
3-story building	35–40 pounds.
5-story building	50 pounds.

187. The flowing test is valuable as showing any important changes or variations in the water supply. For instance, if ordinarily the pressure at bottom of riser drops from 75 to 65 pounds, and then on some test it drops to 50 or 40 pounds, there is probably some undesirable condition which should be rectified.

188. In making any water flow tests, care should be taken that alarm systems are given attention so as not to call apparatus or disturb employees.

189. See Chapter 26 for pump and tank installation and operating points.

COMBINED HEATING AND SPRINKLER SYSTEM

190. A few systems of this kind were installed some years ago but this practice seems to have been generally discontinued. The sprinkler lines were connected at the ends and a return pipe carried to a heater, the discharge from the heater being connected to the bottom of the main riser thus forming a circulating system.

191. The ordinary low temperature sprinkler was used and a small branch pipe used with each sprinkler, this pipe having a bend in which the water did not circulate.

192. While systems of this nature do not seem to be undesirable from a fire protection standpoint, they did not apparently work out well from a heating standpoint, and additional heating units were quite generally used.

GRINNELL SILICA BULB SPRINKLER

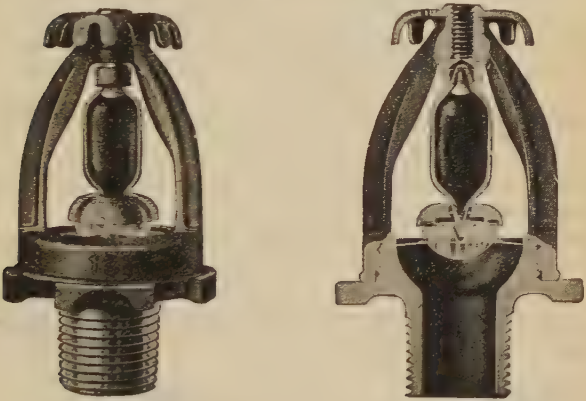


Fig. 76. Grinnell Silica Bulb Sprinkler

193. This sprinkler was approved by the Underwriters' Laboratories in 1922 and operates on an entirely different principle from all other approved sprinklers. In place of a strut of metal parts held together with soft solder, this sprinkler makes use of a capsule or bulb of silica (quartz) filled with a bronze liquid which expands on heat and ruptures the bulb.

194. Silica as used in these sprinklers is a strong transparent material resembling glass in appearance but having very different properties. Its coefficient of expansion is so small that it may be heated to redness and plunged into cold water without injury. On this account bulbs made from it are free from cooling stresses and not subject to failure due to sudden temperature changes.

195. Silica is entirely unaffected by acids except that hydrofluoric acid attacks it very slowly. Moisture does not readily condense on silica so that loading and encrustation in dusty locations is not encouraged.

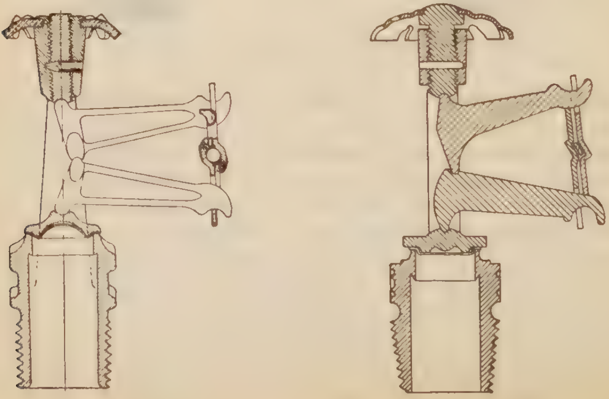
196. The ordinary or low test Bulb sprinkler is designed to operate at 135 degrees F., and unlike the solder sprinkler is not affected by temperatures below the operating temperature. Quicker operation may be expected from the Bulb sprinkler.

197. The Bulb sprinkler would seem to have advantages where there is danger of corrosion or loading as there is no solder or metal strut to be affected by vapor or dust. Where corrosive conditions are unusually severe the bronze metal frame and diaphragm can be coated or enamelled to prevent corrosion.

PHOTOGRAPHS OF AUTOMATIC SPRINKLERS

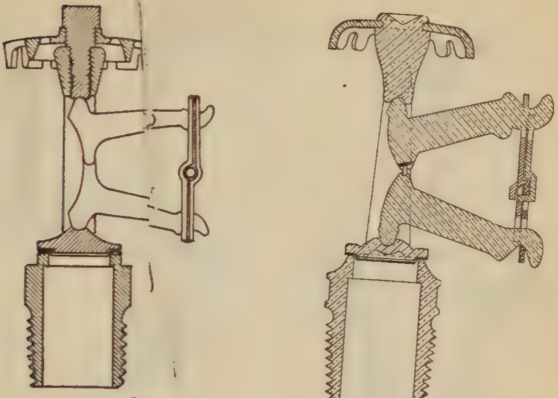
198. The approved types of sprinkler heads are shown in cross section in Figs. 77 to 81, and will be found alphabetically among the photographs Figs. 82 to 100.

199. The photographs of sprinkler heads appearing in the following pages have proved of particular value to field men who have been called upon to pass judgment upon the reliability of sprinkler heads which they encountered in their examinations of plants.



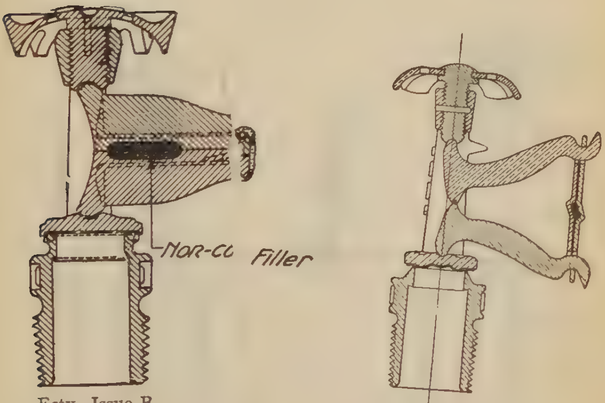
Automatic, Issue A. Central, Issue A.

Fig. 77. Cross Section of Approved Sprinkler Heads.



Crowder, Issue

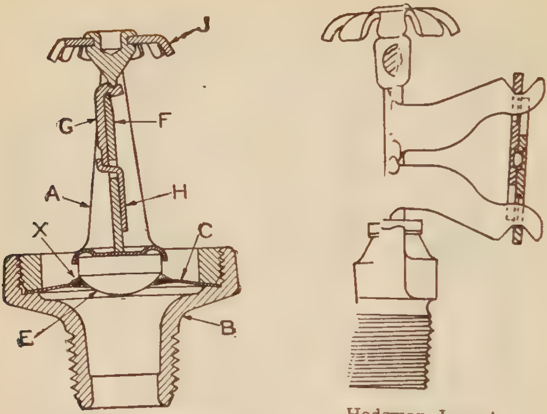
C. S. B., Issue A.



Esty, Issue B.

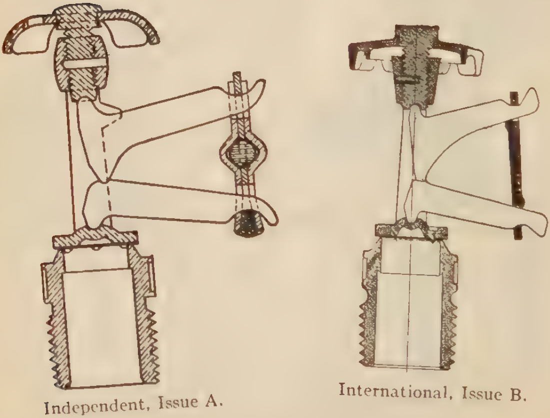
Globe, Issue C.

Fig. 78. Cross Se Approved Sprinkler Heads.



Grinnell, Improved 1903.

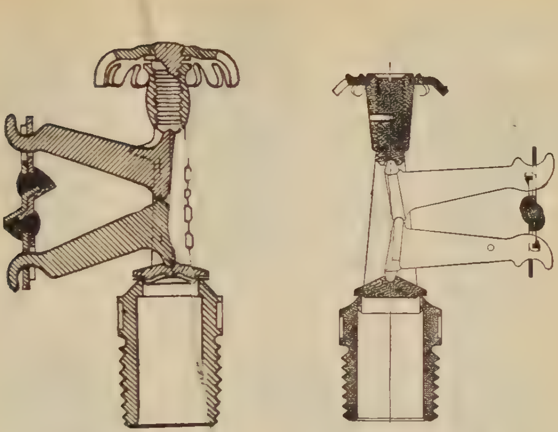
Hodgman, Issue A.



Independent, Issue A.

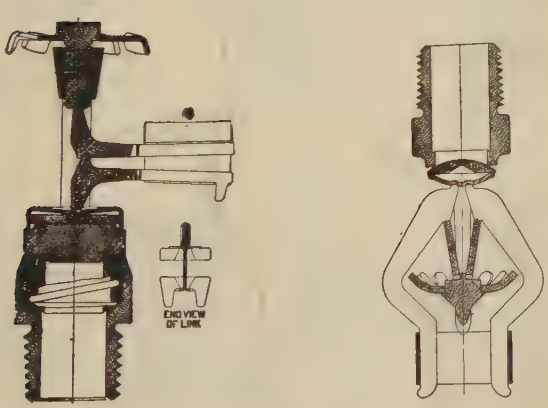
International, Issue B.

Fig. 79. Cross Sectio roved Sprinkler Heads.



K. M. E., Issue B

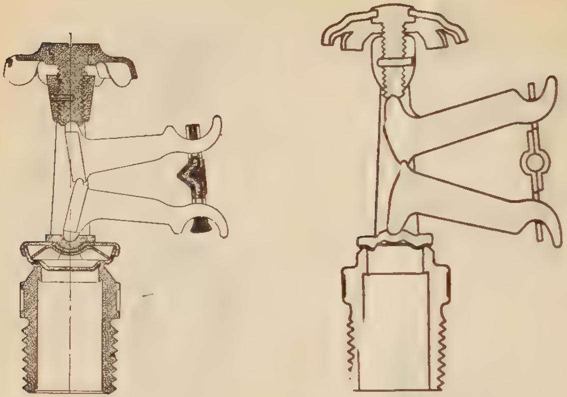
Lapham, Issue B.



Manufacturers, Issue C.

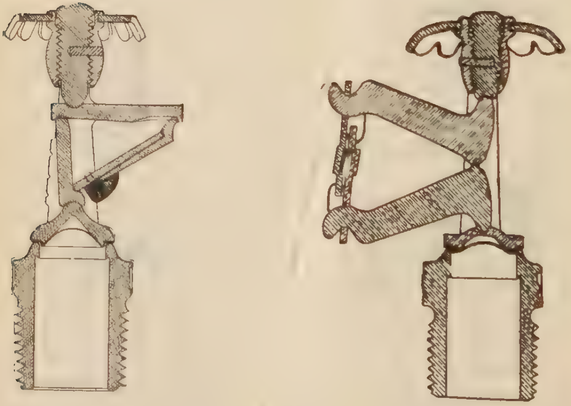
Neracher, Improved 1902.

Fig. 80. Cross Section of pproved Sprinkler Heads.



Niagara, Issue B.

Reliable Issue B.



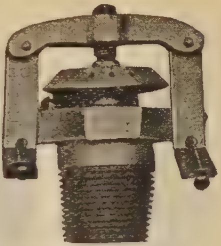
Rockwood, Issue D.

United States, Issue B.

Fig. 81. Cross Section of Approved Sprinkler Heads.

ADKINS 1
1895—(O.)

ADKINS 2
1895—(O.)



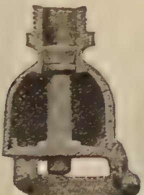
AMERICAN
1892—(O.)

ASSOCIATE A
1913—(A. G.)

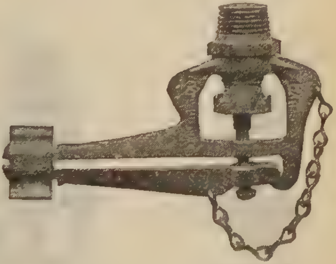
ASSOCIATE B
1914—(A. G.)

AUTOMATIC A
1921—Approved

BABCOCK
1900—(N. U.)



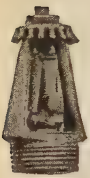
BARNES 1
1881—(O.)



BARNES 2
1885—(O.)

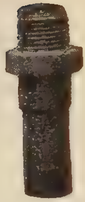
FIG. 82. AUTOMATIC SPRINKLERS.

Notation: A—Formerly approved, but no longer manufactured; F—Fair; G—Good; L—No longer manufactured; N—Nearly obsolete; O—Obsolete; Q—Questionable; U—Unreliable.



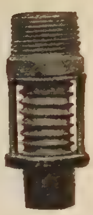
BEECH

1899—(L. U.)
English



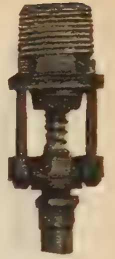
BISHOP 1

1883—(O.)



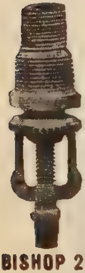
BISHOP 2

1884—(O.)



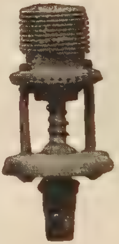
BISHOP 2¼

1884—(O.)



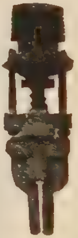
BISHOP 2½

1885—(O)



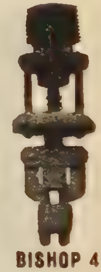
BISHOP 3

1885—(O.)



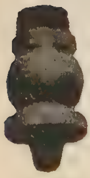
BISHOP 3½

1887—(O)



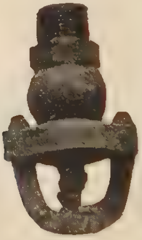
BISHOP 4

1888—(O.)



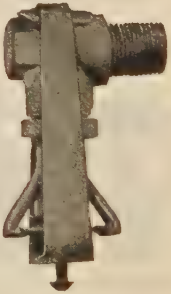
BROWN 1

1881—(O.)



BROWN 2

1884—(O.)

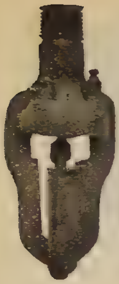


BUELL 1

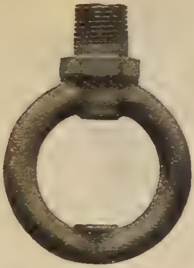
1873—(O)

Fig. 83. Automatic Sprinklers.

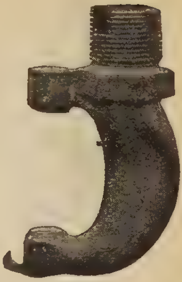
Notation: A—Formerly approved, but no longer manufactured; F—Fair; G—Good; L—No longer manufactured; N—Nearly obsolete; O—Obsolete; Q—Questionable; U—Unreliable.



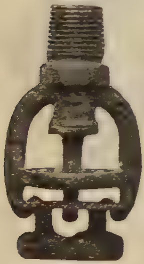
BUELL 2
1884—(O.)



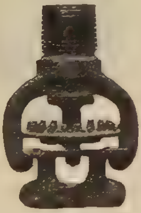
BUELL 3
1884—(O.)



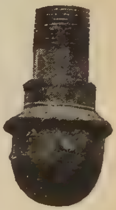
BUELL 4
1885—(O.)



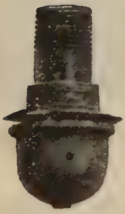
BUELL 5
1886—(O.)



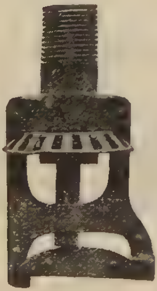
BUELL 6
1892—(O.)



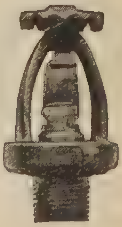
BURRITT 1
1881—(O.)



BURRITT 2
1882—(O.)



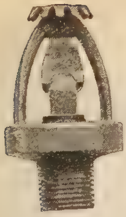
BURRITT 3
1883—(O.)



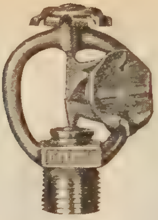
CATARACT A
1906—(L. U.)

Fig. 84. Automatic Sprinklers.

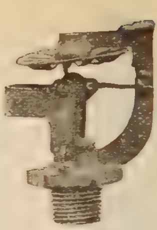
Notation: A—Formerly approved, but no longer manufactured; F—Fair; G—Good; L—No longer manufactured; N—Nearly obsolete; O—Obsolete; Q—Questionable; U—Unreliable.



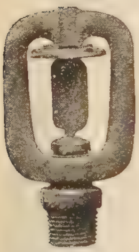
CATARACT B
1907—(L. U.)



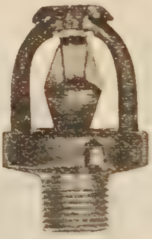
CENTRAL A
1921—Approved



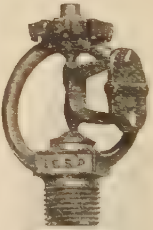
CLAPP 1
1887—(O.)



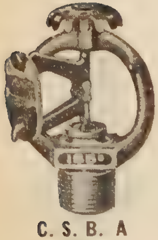
CLAPP 2
1890—(N. Q.)



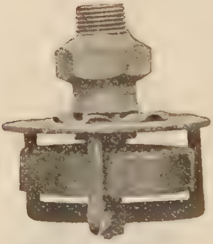
CLAYTON
1906—(O.)



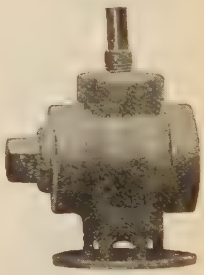
CROWDER A
1909—Approved



C. S. B. A
1921—Approved



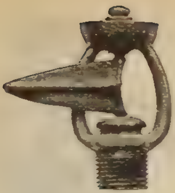
DRAPER
1884—(N. U.)



DRAPER
1889—(N. U.)
Differential

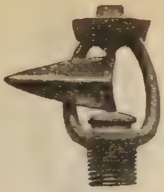
Fig. 85. Automatic Sprinklers.

Notation: A—Formerly approved, but no longer manufactured; F—Fair; G—Good; L—No longer manufactured; N—Nearly obsolete; O—Obsolete; Q—Questionable; U—Unreliable.



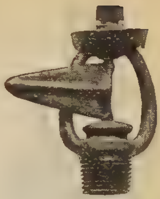
ESTY 1

1895—(O.)
Plain



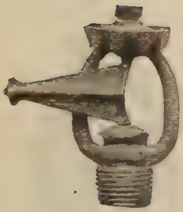
ESTY 2

1895—(O.)
Corrugated



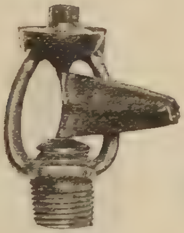
ESTY 3

1895—(O.)
Knob



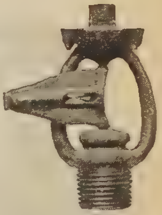
ESTY 4

1895—(O.)
Pin



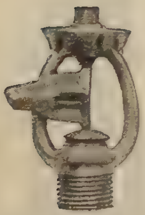
ESTY 4½

1895—(L. U.)



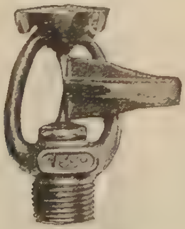
ESTY 5

1896—(L. F.)
Spring



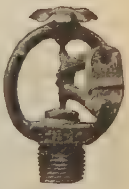
ESTY 6

1903—(L. G.)



ESTY B

1912—Approved
by Mutuals

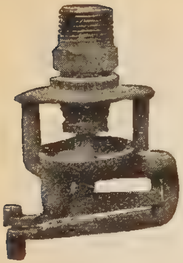


EVANS B

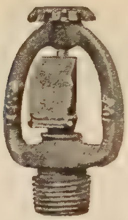
1914—(A. G.)

Fig. 86. Automatic Sprinklers.

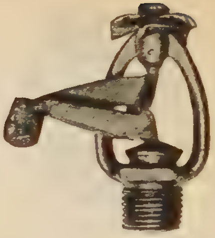
Notation: A—Formerly approved, but no longer manufactured; F—Fair; G—Good; L—No longer manufactured; N—Nearly obsolete; O—Obsolete; Q—Questionable; U—Unreliable.



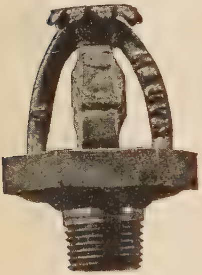
FOWLER
1884—(O.)



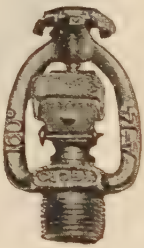
GARRETT
1906—(L. Q.)



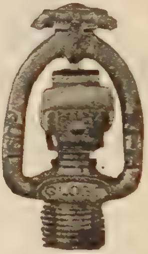
GARTH
1905—Canadian



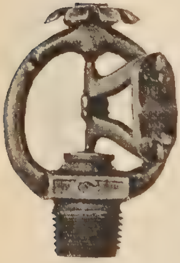
GARTH A
1914—Approved
by Mutuals
Canadian



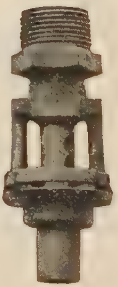
GLOBE A
1911—(A G.)



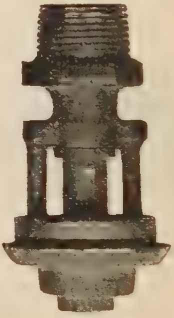
GLOBE B
1914—(A G.)



GLOBE C
1916—Approved



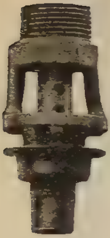
GRAY 1
1884—(O.)



GRAY 1½
(O.)

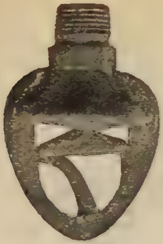
FIG. 87. AUTOMATIC SPRINKLERS.

Notation: A—Formerly approved, but no longer manufactured; F—Fair; G—Good; L—No longer manufactured; N—Nearly obsolete; O—Obsolete; Q—Questionable; U—Unreliable.



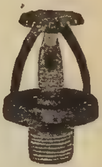
GRAY 2

1886—(O.)



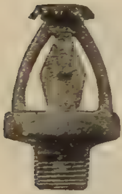
GRINNELL A.B.C.D.

1882-1900—(L. U.)
Metal Disc



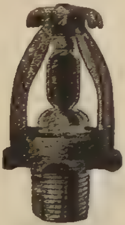
GRINNELL

1890 - (O.)
Glass Disc—First Type



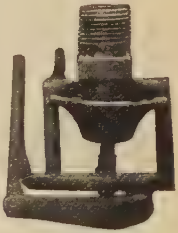
GRINNELL

1903—Approved
Glass Disc—Improved



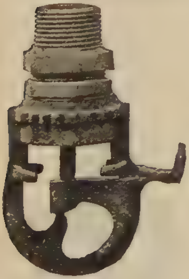
**GRINNELL
SILICA BULB**

Approved—1923



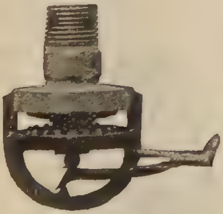
GUNN

1885—(O.)



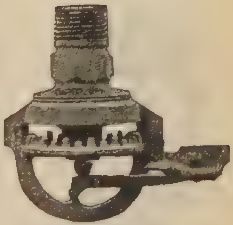
HARKNESS 1

1887—(O.)



HARKNESS 2

1889—(O.)
L Joint

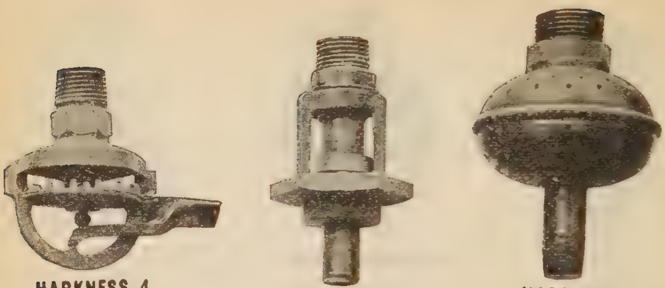


HARKNESS 3

1890 - (O.)
Rect. Joint

Fig. 88. Automatic Sprinklers.

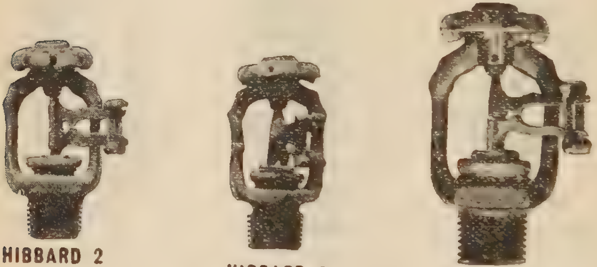
Notation: A—Formerly approved, but no longer manufactured; F—Fair; G—Good; L—No longer manufactured; N—Nearly obsolete; O—Obsolete; Q—Questionable; U—Unreliable.



HARKNESS 4
1894—(O.)
V Joint

HARRIS
1883—(O.)

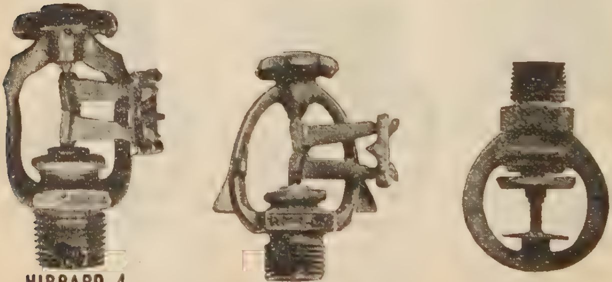
HARRISON
1864—(O.)
English



HIBBARD 2
1894—(L. U.)

HIBBARD 3
1894—(L. U.)

HIBBARD 3A
1898—(L. U.)



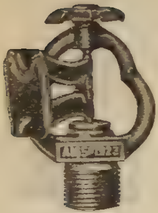
HIBBARD 4
1901—(L. Q.)

HIBBARD H & I
1911—(A. G.)

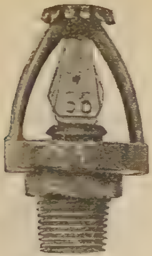
HILL
1890—(L. Q.)

Fig. 89. Automatic Sprinklers.

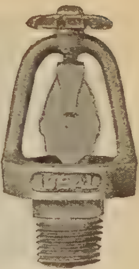
Notation: A—Formerly approved, but no longer manufactured; F—Fair; G—Good; L—No longer manufactured; N—Nearly obsolete; O—Obsolete; Q—Questionable; U—Unreliable.



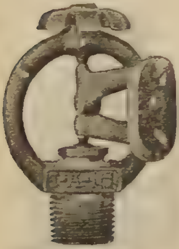
HODGMAN A
1921—Approved



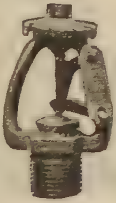
HOFFMAN
English



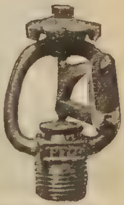
IDEAL A
1914—(L.)



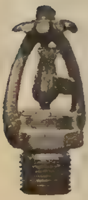
INDEPENDENT A
1916—Approved



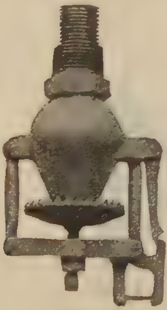
INTERNATIONAL 1
1900—(L, Q.)



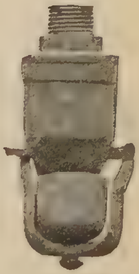
INTERNATIONAL B
1906—Approved



JAHN
1891—(O.)



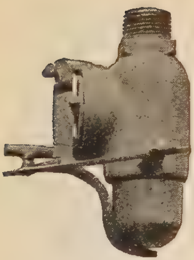
JORDON
1885—(O.)



W. KANE 1
1881—(O.)

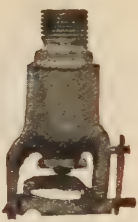
FIG. 90. AUTOMATIC SPRINKLERS.

Notation: A—Formerly approved, but no longer manufactured; F—Fair; G—Good; L—No longer manufactured; N—Nearly obsolete; O—Obsolete; Q—Questionable; U—Unreliable.



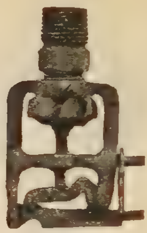
W. KANE 2

1882—(O.)
Eclipse



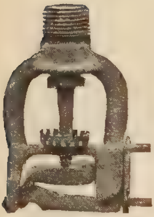
W. KANE 3

1888—(O.)
Bulb Root



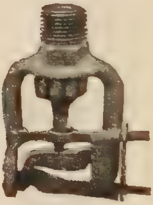
W. KANE 4

1892—(L. Q.)
Perfection



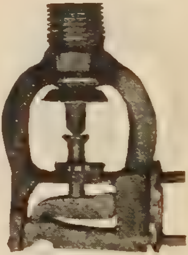
J. KANE 1

1892—(L. Q.)
Universal



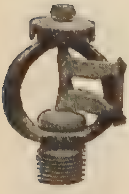
J. KANE 2

1892—(L. Q.)
Universal



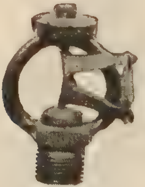
J. KANE 2½

1892—(L. Q.)



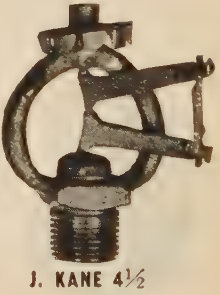
J. KANE 3

1900—(L. Q.)



J. KANE 4

1902—(L. Q.)

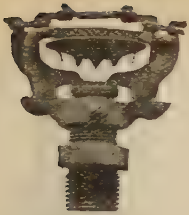


J. KANE 4½

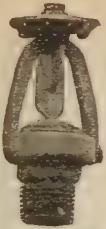
1902—(L. Q.)

FIG. 91. AUTOMATIC SPRINKLERS.

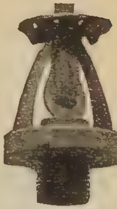
Notation: A—Formerly approved, but no longer manufactured; F—Fair; G—Good; L—No longer manufactured; N—Nearly obsolete; O—Obsolete; Q—Questionable; U—Unreliable.



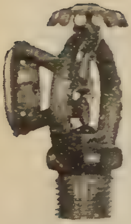
KERSTETTER 1
1888—(O.)



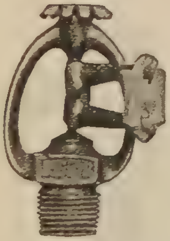
KERSTETTER 2
1893—(N. U.)



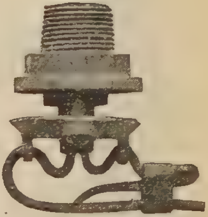
KERSTETTER 3
1898—(L. U.)



K M.E. B
1920—Approved



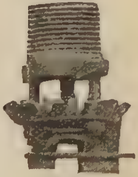
LAPHAM B
1911—Approved



MACKEY 1
1883—(O.)

MACKEY 2
1885—(O.)

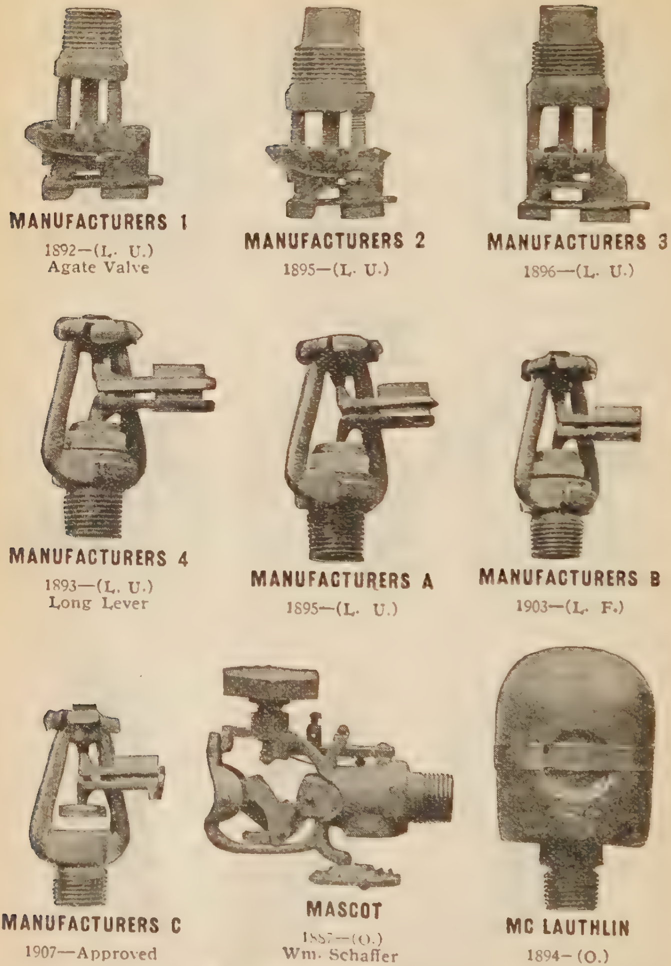
MACKEY 3
1887—(O.)



MACKEY 4
1888—(N. U.)
Metal Valve

FIG. 92. AUTOMATIC SPRINKLERS.

Notation: A—Formerly approved, but no longer manufactured; F—Fair; G—Good; L—No longer manufactured; N—Nearly obsolete; O—Obsolete; Q—Questionable; U—Unreliable.



MANUFACTURERS 1
1892—(L. U.)
Agate Valve

MANUFACTURERS 2
1895—(L. U.)

MANUFACTURERS 3
1896—(L. U.)

MANUFACTURERS 4
1893—(L. U.)
Long Lever

MANUFACTURERS A
1895—(L. U.)

MANUFACTURERS B
1903—(L. F.)

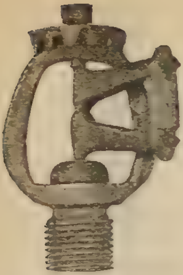
MANUFACTURERS C
1907—Approved

MASCOT
1887—(O.)
Wm. Schaffer

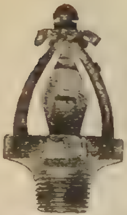
MC LAUTHLIN
1894—(O.)

FIG. 93. AUTOMATIC SPRINKLERS.

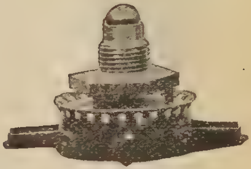
Notation: A—Formerly approved, but no longer manufactured; F—Fair; G—Good; L—No longer manufactured; N—Nearly obsolete; O—Obsolete; Q—Questionable; U—Unreliable.



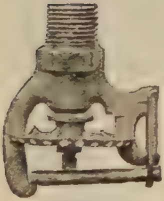
MORRIS
English (U.)



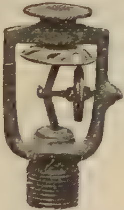
MORRISON
Canadian



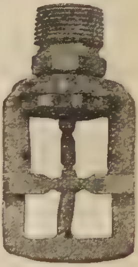
NAGLE 1
1890—(O.)



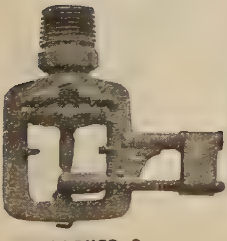
NAGLE 2
1891—(O.)



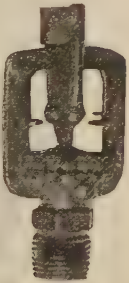
NAYLOR
1895—(O.)



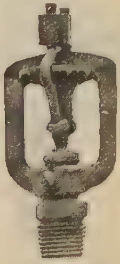
NERACHER 1
1884—(O.)



NERACHER 2
1887—(O.)



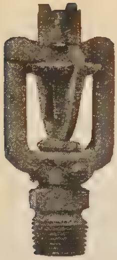
NERACHER 2½
1887—(L. U.)



NERACHER 3
1888—(L. Q.)

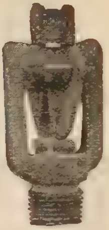
FIG. 94. AUTOMATIC SPRINKLERS.

Notation: A—Formerly approved, but no longer manufactured; F—Fair; G—Good; L—No longer manufactured; N—Nearly obsolete; O—Obsolete; Q—Questionable; U—Unreliable



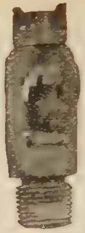
NERACHER 3½

1893—(L. Q.)



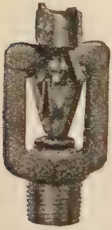
NERACHER 4

1895—(L. Q.)



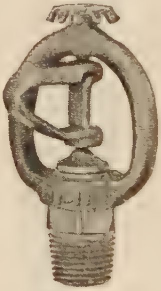
NERACHER 5

1902—(L. F.)



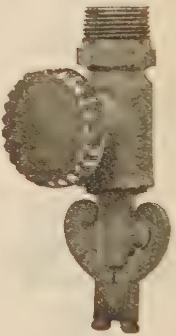
NERACHER 6

1902—Approved
Improved



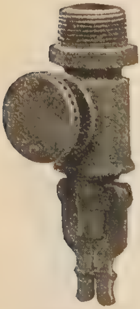
NEW YORK

1911—(L. U.)



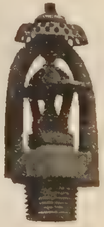
N. Y. & N. H. 1

1889—(O.)



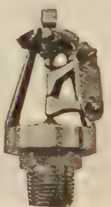
N. Y. & N. H. 2

1889—(O.)



NEWTON

1894—(O.)

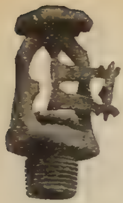


NEWTON

English

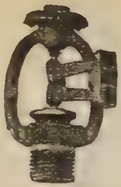
FIG. 95. AUTOMATIC SPRINKLERS.

Notation: A—Formerly approved, but no longer manufactured; F—Fair; G—Good; L—No longer manufactured; N—Nearly obsolete; O—Obsolete; Q—Questionable; U—Unreliable.



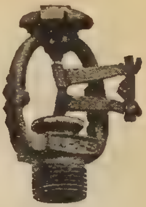
NIAGARA-HIBBARD A

1902—(L. U.)



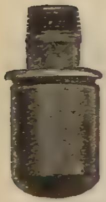
NIAGARA-HIBBARD B

1904—(L. F.)



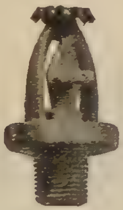
NIAGARA B

1912—Approved



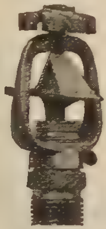
PARMELEE

1878—(O.)



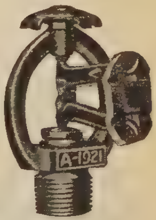
PHOENIX A

1905—(L. F.)



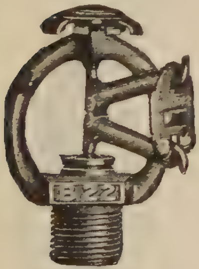
PIERCE

1894—(N. U.)



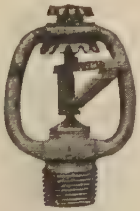
RELIABLE A

1921—(A.)



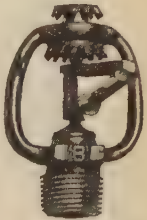
RELIABLE B

1921—Approved



ROCKWOOD A

1906—(O.)

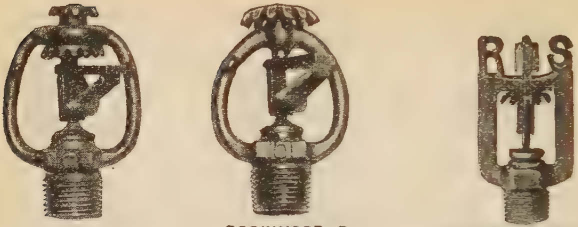


ROCKWOOD B

1906—(L. G.)

FIG. 96. AUTOMATIC SPRINKLERS.

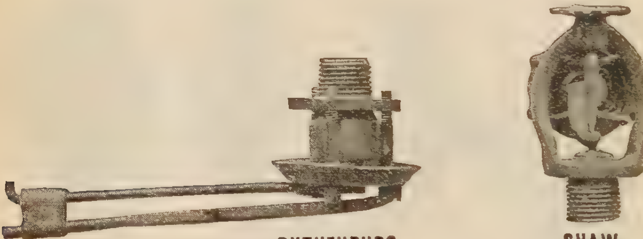
Notation: A—Formerly approved, but no longer manufactured F—Fair; G—Good; L—No longer manufactured; N—Nearly obsolete; O—Obsolete; Q—Questionable; U—Unreliable.



ROCKWOOD C
1910—(A. G.)

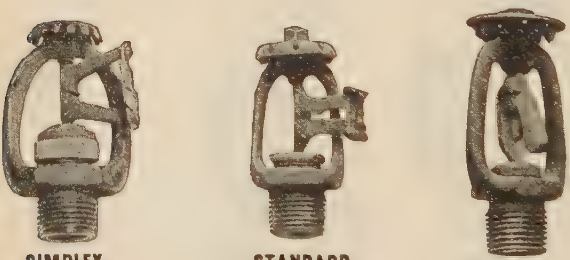
ROCKWOOD D
1911—Approved

RUNDELL SPENCE A
1913—(A G.)



RUTHENBURG
1885—(O.)

SHAW
1897—(L. U.)



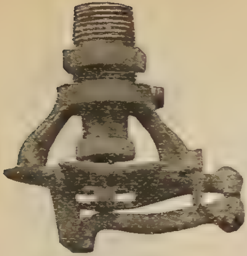
SIMPLEX
1902—(O.)

STANDARD
1902—(N. U.)

STANTIAL
1895—(L. U.)

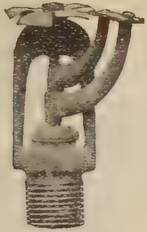
Fig. 97. Automatic Sprinklers.

Notation: A—Formerly approved, but no longer manufactured; F—Fair; G—Good; L—No longer manufactured; N—Nearly obsolete; O—Obsolete; Q—Questionable; U—Unreliable.



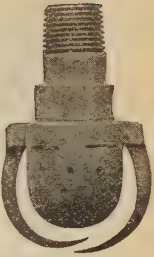
STAR

1886—(O.)



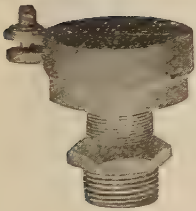
SWAN 2

1895—(N. U)



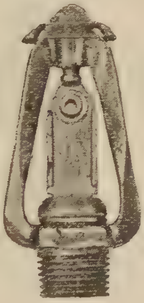
TALCOTT

1882—(O.)



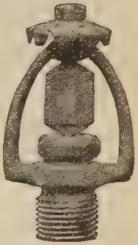
TITAN 1

English



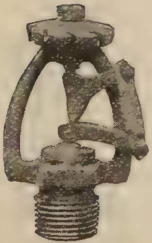
TITAN 2

English



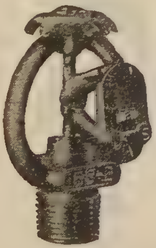
UNIVERSAL 1

1896—(O.)



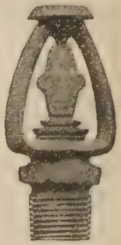
UNIVERSAL 2

1899—(O.)



U. S. B

1923—Approved

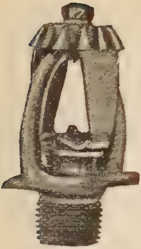


UP TO DATE

1899—(L. U)

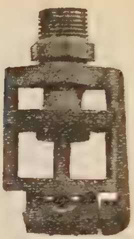
FIG. 98. AUTOMATIC SPRINKLERS.

Notation: A—Formerly approved, but no longer manufactured; F—Fair; G—Good; L—No longer manufactured; N—Nearly obsolete; O—Obsolete; Q—Questionable; U—Unreliable.



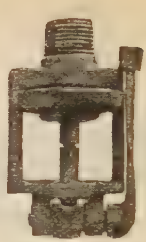
VOGEL (LACONIA)

1904—English



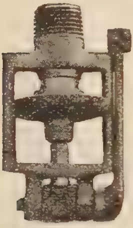
WALWORTH 1

1883—(O.)
Soldered Arm



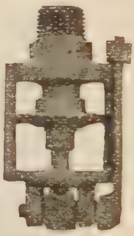
WALWORTH 2A

1883—(O.)
Drop Deflector



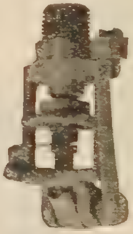
WALWORTH 3

1885—(O.)
Soldered Deflector



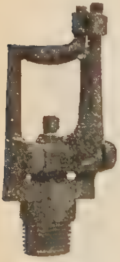
WALWORTH 4

1888—(N. U.)
Ordinary



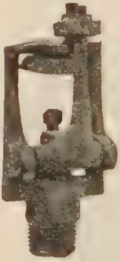
WALWORTH 5

1888—(O.)
Upright Spring



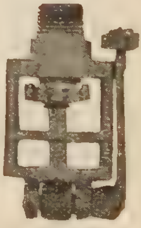
WALWORTH 6

1892—(O.)
Smooth Deflector



WALWORTH 7

1894—(N. U.)
Ordinary

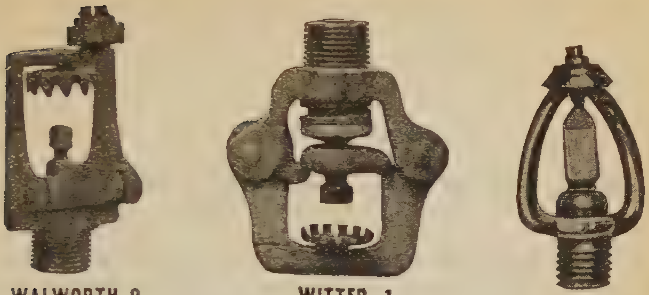


WALWORTH 8

1898—(L. U.)
Improved Pendent

FIG. 99. AUTOMATIC SPRINKLERS.

Notation: A—Formerly approved, but no longer manufactured; F—Fair; G—Good; L—No longer manufactured; N—Nearly obsolete; O—Obsolete; Q—Questionable; U—Unreliable.



WALWORTH 9
1899—(L. U.)
Improved Upright

WITTER 1
English

WITTER E
1906—English

FIG. 100. AUTOMATIC SPRINKLERS.

Notation: A—Formerly approved, but no longer manufactured; F—Fair; G—Good; L—No longer manufactured; N—Nearly obsolete; O—Obsolete; Q—Questionable; U—Unreliable.

CHAPTER 30

RULES AND REQUIREMENTS FOR AUTOMATIC SPRINKLER SYSTEMS

1. The 1922 edition of the Rules and Requirements for Automatic Sprinkler Systems are reprinted in this chapter in full, except when portions are found in other chapters, in which case special reference will be made to points where rules can be found.

2. The most important changes since the last edition of this Hand Book are with reference to Dry Systems. (See Chap. 32.)

INTRODUCTION

3. The rules contained herein cover the general details of a sprinkler equipment only. Before an equipment is installed, or before a present equipment is remodeled, complete working plans should be submitted for approval to the Inspection Department having jurisdiction.

4. These plans should be drawn to an indicated scale; give correct address and points of compass; show sectional elevations of the buildings; and the essential features of the construction, viz., size, location, and direction of joists, timbers or other structural members. They should also indicate the location and size of water supplies, connecting pipes, feed mains and risers, gate, check, alarm, and dry-pipe valves, as well as the location, spacing, number, and type of sprinklers.

5. Inspection Department having jurisdiction and the lists published by the Underwriters' Laboratories should be consulted as to standard makes of automatic and open sprinklers, gate, check, alarm and dry-pipe valves, indicator posts, and hydrants.

6. See also Sketches for Dry Pipe Valve Enclosures, separately published as a supplement to these regulations. Obtainable on application.

7. For regulations governing the installation of Fire Pumps, Gravity and Pressure Tanks, Valves, Indicator Posts, and Hydrants, see separate publications of the National Board of Fire Underwriters and Underwriters' Laboratories.

SECTION A—GENERAL INFORMATION

1. Preparation of Building—Many buildings require preparation for sprinkler equipment. All needless ceiling sheathing, hollow siding, tops of high shelving, needless partitions or decks should be removed. Necessary "stops" to check draft, necessary new partitions, closets, decks, etc., should be put in place, or provided for, so that the equipment may conform to same. The top flooring should be made thoroughly tight. Paper or similar light inflammable ceiling sheathing is objectionable and unnecessary. (See Section B, Rule 13.)

Authors' Note—It must be distinctly borne in mind when a sprinkler system is installed, that account must be taken of the construction features of a building including any fixtures which may obstruct the distribution of water. To the same end, any changes in construction may require addition to or changes in the sprinkler systems, and the underwriters should be consulted in every case.

2. Accessory Construction—Sprinkler equipments require accessory construction, dry-pipe valve closets, ladders, anti-freezing boxing for tank, pipes, etc. This work should be promptly attended to if not let with sprinkler contract.

Authors' Note—There is frequently a misunderstanding between the contractor and the property owner as regards carpenter work. It is generally left to the property owner which frequently means considerable outlay after the pipe system is finished. The underwriters should be consulted as to details and approved methods for all of this carpenter work.

3. Vertical or Horizontal Drafts—Floor or wall openings tending to create vertical or horizontal drafts, or other structural defects that would prevent the prompt operation of automatic sprinklers by preventing the banking up of the heated air from the fire, should be properly "stopped" in order to permit specific control by the local sprinklers.

Curtain-boards at least 12 inches deep or other horizontal draft-stops shall be provided to overcome such structural defects. See Fig. 101.

Except in special cases the main feeders to sprinklers are only of sufficient size to supply the sprinklers on one floor, consequently it is absolutely essential that these requirements for protection of vertical shafts should be carried out in every detail, and where extraordinary conditions exist and there is likelihood of fire passing through unprotected openings, pipe sizes should be increased accordingly.

Authors' Note—Unprotected vertical openings are among the most serious defects, and if fire starts near same it almost always means the opening of a larger number of sprinklers, thus increasing the water and smoke damage and possibly overtaxing the water supplies. Curtain boards are of great value in large area, high studded rooms, or buildings. These should run across the building and extend down from the roof or ceiling as far as feasible. Preferably they should be of non-combustible material, such as sheet metal or wire lath and cement plaster. They should be placed from 50 to 100′ apart, the object being to confine the heat to a comparatively small area and prevent the opening of sprinklers at considerable distance from the fire. They also act as a temporary retardant making it less easy for fire quickly to spread the entire length of building. Pier warehouses and other large one-story buildings of similar type should have curtain boards and where the width is over 100′ curtain boards running parallel with the width of the building are also desirable. In car houses curtain boards can be dropped from the roof or ceiling at every other space between tracks, these being constructed of expanded metal and cement and extending to approximately the level of car roof. The aisle sprinklers can be located directly under such curtain boards and attached to same.

4. Clear Space Below Sprinklers—Full effective action of sprinklers requires about 24 inches wholly clear space **below the sprinklers**, so that they may form an unbroken spray blanket from sprinkler to sprinkler and sides of room. Any stock piles, racks, or other obstructions interfering with such action are not permissible. Sprinkler piping should not be used for the support of stock, clothing, etc.

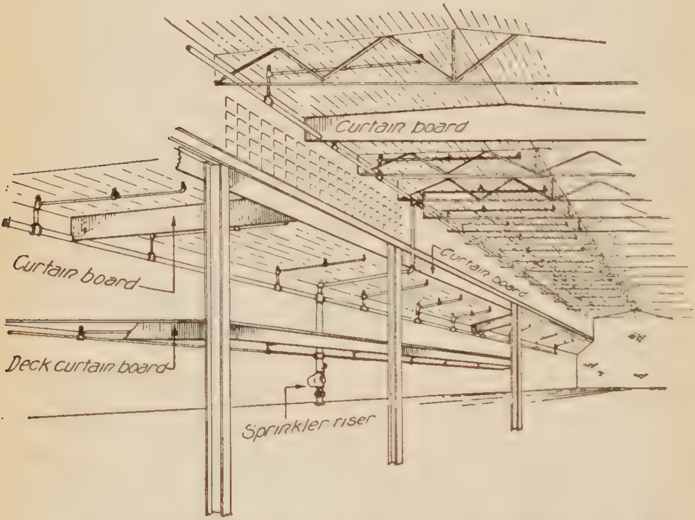


FIG. 101. CURTAIN BOARDS TO BANK HEAT AROUND SPRINKLER HEAD

Authors' Note—This is a very important matter. Water from sprinklers cannot be relied upon to control a fire if the distribution is impaired by cases or other obstructions piled around or near the sprinkler heads.

5. Experienced Workmen Recommended—Sprinkler installation is a trade in itself. Inspectors cannot be expected to act as working superintendents, or correct errors of beginners. Sprinkler work should be entrusted to none but fully experienced and responsible parties.

Care must be taken that after pipes are cut they are properly reamed in order to remove all burrs and fins; also that threads are cut to standard so that joints will be properly made without obstructing waterway. In applying the joint compound, care should be taken to place it on the pipe and not the fitting.

All distributing pipes must be straightened before installation, in order to prevent pockets between hangers which would interfere with the proper drainage of the system.

Authors' Note—At the annual meeting of the National Fire Protection Association in 1903, the following resolution was adopted:

Whereas, It has been the practice of the automatic sprinkler companies to sell sprinklers to be installed by others, and as this practice is growing to the detriment of reliable and satisfactory automatic sprinkler installation; and

Whereas, Our members have experienced much difficulty in having equipments properly installed, under such conditions, in accordance with our rules; be it

Resolved, That it is the sentiment of the National Fire Protection Association that automatic sprinklers should be installed by the recognized automatic sprinkler companies, and should not be sold to be erected by those not experienced in the installation of an automatic sprinkler equipment, unless such installations be guaranteed to comply with the rules of the National Board of Fire Underwriters by the sprinkler company furnishing the devices installed.

6. All Portions of Buildings to be Protected—Experience teaches that sprinklers are often necessary where seemingly least needed. Their protection is required not alone where a fire may begin, but also wherever any fire might extend, including wet or damp locations.

Authors' Note—The fallacy of attempting to pick out the places where a fire will or will not start has long been proven. Vacant basements, blind attics, concealed spaces, etc., etc., all need sprinkler protection. Two mills equipped with sprinklers were total losses due to the fact that fire originated over the water in canal or tail race, and under the building, i.e., in a place where it was next to impossible for a fire to start.

7. Degree of Protection—A maximum protection cannot be expected where sprinklers are at more or less permanent disadvantage, as in the case of stocks very susceptible to smoke and water damage, buildings having deep piles of hollow goods, excessive draughts, explosion or flash fire hazards, large amounts of benzine or similar fluids, or where long subject to low temperatures, as in refrigerator rooms.

Inspection departments having jurisdiction shall be consulted as to the advisability of installing sprinklers where the application of water or flame and water to the contents may constitute a serious life or fire hazard, as in the manufacture or storage of quantities of aluminum powder, calcium carbide, calcium phosphide and metallic sodium, and potassium. The manufacture and storage of such materials should be confined to specially cut-off and unsprinklered rooms or buildings of fire-resistive construction. It is also advisable to confine storage in quantities of quicklime, magnesium powder, and sodium peroxide to such rooms or buildings.

Authors' Note—It is also well to call attention to high-studded rooms where sprinklers may be at a considerable distance from the seat of the fire and where drafts may cause a large number of sprinklers to open. Buildings or rooms also exist where, owing to corrosive vapors, the sprinklers and piping deteriorate, and although, as has been mentioned, this can be materially retarded by proper coatings, the protection is necessarily less dependable and frequent renewals at both piping and sprinklers may be necessary. (See Chapter 29 for efficiency of sprinklers in various classes of occupancy.)

8. Necessary Cut-offs—Sprinklers cannot be expected to keep out fire originating in unsprinklered territory. Stringent measures should be used to properly cut off all unsprinklered portions of buildings or exposures.

Authors' Note—For best protection all portions of the property should be equipped with sprinklers and there should be no openings into adjoining buildings which are not equipped.

9. Communications—When a building fully equipped with sprinklers communicates with another not so equipped, the openings must be protected by standard fire doors on both sides of the walls, one of which must be automatic.

10. Protection Against Exposures—The danger of sprinkler protection being impaired by exposure fires should be reduced by providing at exposed openings one or more of the following: Shutters, wired glass, or open sprinkler protection.

SECTION B—LOCATION OF AUTOMATIC SPRINKLERS

11. Position of Sprinkler—Shall be located in an upright position.
When construction or occupancy of a room or enclosure makes it preferable, permission may be given, except on dry-pipe systems, to locate sprinklers in a pendant position.

Authors' Note—When upright, the sprinkler and its fitting will not constitute a repository for sediment, can be entirely drained, and the pipe shields sprinkler against damage. On the other hand, it necessitates a lower position for the piping and care must be taken lest deflectors are located nearer the ceiling than allowed.

12. Position of Deflectors—Sprinkler deflectors shall be parallel to ceilings, roofs, or the incline of stairs, but when installed in the peak of a pitched roof they shall be horizontal. Distance of deflectors from ceilings of mill or other smooth construction, or bottom of joists of open joist construction, shall be not less than 3 inches nor more than 10 inches; 6 to 8 inches is the best distance with average pressure and present types of sprinklers. Note particularly that the rule for distance refers to the deflector of the sprinkler.
In the case of fire-resistive buildings, the distance between deflectors and ceilings may be increased where conditions warrant, i.e., under panel ceilings. In semi-mill or other unusual construction, consult the Inspection Department having jurisdiction.

Authors' Note—Care should be taken to have the deflectors of sprinklers in the peak of a pitched roof a considerable distance from the rafters, but not exceeding 10 inches. Sprinkler distribution is at best at a disadvantage under open joists ceilings and commonly the deflectors are located too near the joists, being crowded upon ends of lines to the limit or in violation of the rules.
A distance of some 6 inches would give the best results with the average type of sprinkler and water pressure.

13. Detailed Locations—Sprinklers shall be placed throughout premises, including basement and lofts, under stairs, inside elevator wells, in belt, cable, pipe, gear, gear and pulley boxes, inside small enclosures, such as drying and heating boxes, tenter and dry-room enclosures, chutes, conveyor trunks and all cupboards and closets unless they have tops entirely open, and are so located that sprinklers can properly spray therein. Sprinklers are not to be omitted in any room merely because it is damp, wet or of fire-resistive construction. (See also Section N, Railway Car Houses.)

Special Pamphlets—(See also separately published Regulations for the torage, Handling, and Use of Pyroxylin Plastics in Factories Making Articles Therefrom, and the separately published Regulations governing the Production, Storage, and Handling of Nitro-Cellulose Motion Picture Films for Sprinkler Installation Under Conditions There Outlined.)

Small Enclosures—Special instructions should be obtained from Inspection Department having jurisdiction relative to placing sprinklers inside show windows, telephone booths, boxed machines, metal air ducts, ventilators and concealed spaces, and under large shelves, benches, tables, overhead storage racks, platforms and similar water-sheds, and over electrical generating and transforming apparatus and switchboards. All combustible blind spaces in floors or ceilings where variation in pitch occurs shall be provided with sprinkler protection up to the point where a 4-inch clearance prevails between upper and lower joists.

Decks—In connection with the foregoing, the following should govern: Unless sprinklers are placed underneath, decks or galleries should not exceed 42 inches in width, or be placed directly against walls or partitions. A 6-inch clearance shall be maintained, and the back of the gallery or deck should be framed in to keep stock clear of the opening.

Fixtures—Fixtures should not exceed 5 feet in width, and where their width exceeds 30 inches should be bulkheaded with tight partitions; compartments shall not be more than 5 feet deep, 8 feet long, and 3 feet high.

Tables—Tables more than 42 inches in width and less than 5½ feet in width should be provided with tight upright partitions not exceeding 8 feet on ceters: tables wider than 5½ feet should be provided with sprinkler protection underneath.

Authors' Note—Too much stress cannot be laid upon the vital importance of thoroughly installing sprinklers within all enclosures. A fire within even a small enclosure may continue burning untouched by the spray from sprinklers on ceiling of a room and the heat evolved gradually opens up sprinkler after sprinkler, accomplishing an unnecessary water damage, if not overtaxing the water supply so that when fire finally breaks through, it may spread unchecked by the diminished sprinkler discharge.

Special attention should always be called to benches, racks, or large tables, these being common in many classes of risk and frequently disregarded so far as sprinkler protection is concerned.

14. Protection of Vertical Shafts—In vertical shafts having inflammable sides, a sprinkler shall be provided within shaft for each 200 square feet of inflammable surface, in addition to sprinklers at tops of shafts. Such sprinklers should be installed at each floor when practicable, and always when shaft is trapped.

Where practicable, sprinklers should be "staggered" at the alternate floor levels, particularly when only one sprinkler is installed at each floor level.

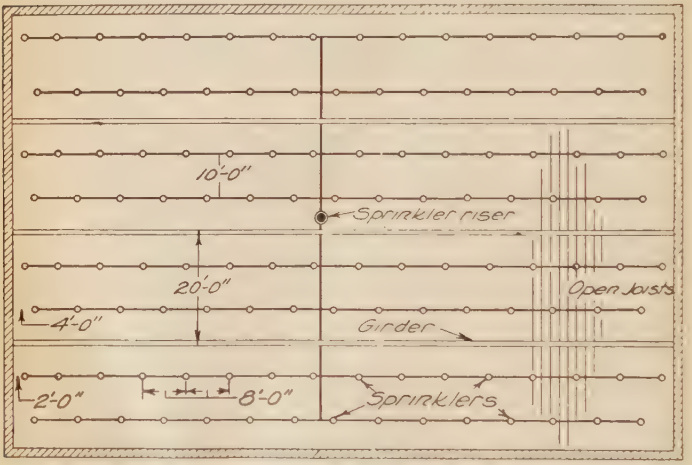
Authors' Note—One sprinkler at the top of an elevator shaft will not protect its wall surfaces at stories beneath. Where there is not room for the heads within shaft on each floor, they should be located in enclosed offsets.

So far as top of elevator shaft is concerned one sprinkler of the ordinary type should suffice if shaft area is not over 64 square feet. If more than this it is preferable to use two or more ordinary sprinklers. The so-called "Jumbo" sprinkler is not recommended.

SECTION C—SPACING OF AUTOMATIC SPRINKLERS

Note: For Railway Car Houses see Section N.

15. Distance from Walls—The distance from wall or partition to first sprinkler shall not exceed one half the allowable distance between sprinklers in the same direction. Additional sprinklers may also be required in the narrow pockets formed by bay timbers or beams and wall.



Case A

Fig. 102. Method of Spacing Sprinkler Heads
Joisted

Authors' Note—It is deemed good practice to locate the heads even nearer to combustible walls and partitions. Furthermore, with staggered or other special spacing it may be desirable to locate certain sprinklers considerably nearer the wall than is called for by the above rule.

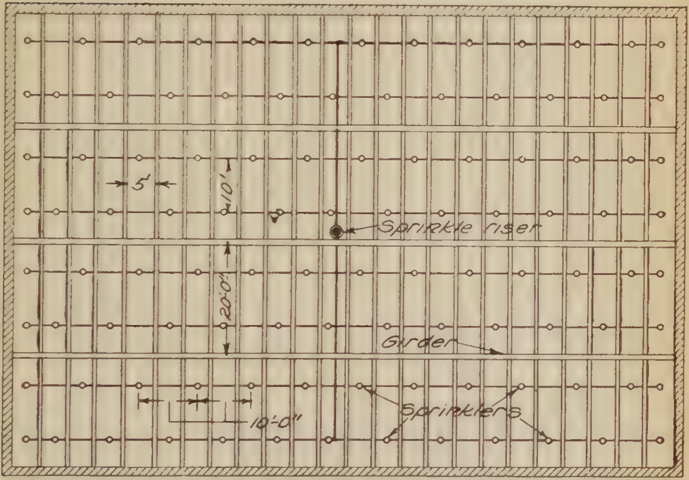
16. Partitions or Other Obstructions—A line of sprinklers should be run on each side of the partition. Cutting holes through a partition to allow sprinklers on one side thereof to distribute water to the other side is not effectual. This rule applies to both solid and slatted partitions.

Where no combustible material is stored close to the ceiling, the Inspection Department having jurisdiction may waive the requirement for providing extra sprinklers in narrow pockets formed by beams and partitions, where the construction is entirely fire-resistive, including the partitions.

Heads should not be placed closer than 12 inches to uprights, ceiling blocking, hangers, or other obstructions.

17. Mill Construction—Under mill ceiling (smooth solid plank and timber construction, 5 to 12 foot bays) one line of sprinklers should be placed in center of each bay and distance between the sprinklers on each line should not exceed the following:

8 feet in 12 foot bays.
9 feet in 11 foot bays.
10 feet in 10 foot bays.
11 feet in 9 foot bays.
12 feet in 5 to 8 foot bays.



Case B.
FIG. 103. METHOD OF SPACING SPRINKLER HEADS.
(5'–0" × 20'–0" Fire Proof Bays.)

Measurements should be taken from center to center of timbers. See Figs. 103, 104, and 105.

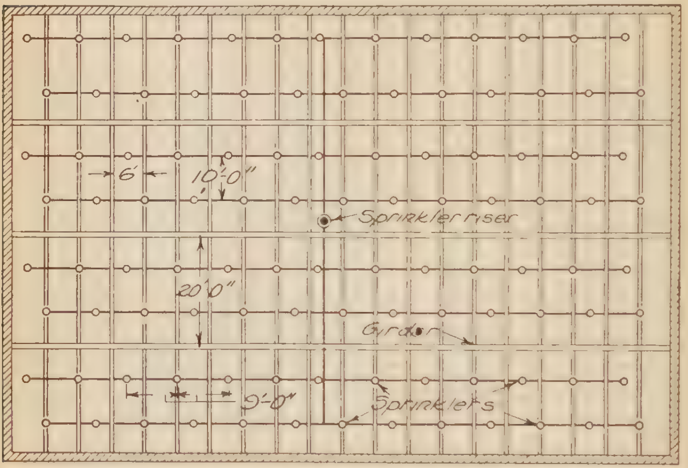
Ceilings of modified mill construction having bays less than three feet should be treated as open joist construction and sprinkler heads spaced accordingly.

Bay timbers spaced three feet or more on centers, but less than five feet on centers, will require special ruling by the Inspection Department having jurisdiction.

Authors' Note—This rule defines a mill ceiling as one with 5 to 12 feet bays. That is, anything less than 5 feet is unprovided for and becomes a question of special ruling. Where bays are under 5 feet and a line of sprinklers is not run in each bay, but at right angles to the timbers, the construction partakes of the nature of joisted construction, for the timbers obstruct the distribution. It would seem to be a fair ruling in such cases that sprinklers shall not be over 8 feet apart on the line (i. e., at right angles to timbers) and also they must be staggered spaced.

18. Joisted Construction (a) Open Joist—Under open finish joisted construction, ceilings, floors, decks, and roofs, the lines shall be run at right angles to the joists and the sprinklers "staggered spaced," so that heads will be opposite a point half way between sprinklers on adjacent lines, and the distance between sprinklers not exceeding 8 feet at right angles to the joists or 10 feet parallel with joists; the end heads on alternate lines being not more than 2 feet from wall or partition. Also see Rule 15.

Exception—An exception may be made to this rule *if the conditions warrant,* viz., *special permission* may be given to install but one line of sprinklers in bays 10 to 11½ feet wide from center to center of the timbers which support the joists. In all cases where such bays are over 11½ feet wide, two or more lines of sprinklers should be installed in *each bay* as required by the rules for spacing. This does not apply where beams are flush with the joists, in which case sprinklers may be spaced as called for in Rule 18. Where permission is given, the sprinklers should be placed closer together on a line so that in no case will the area covered by a single sprinkler exceed 80 square feet. Also see Rule 22. See Fig. 102.



Case C

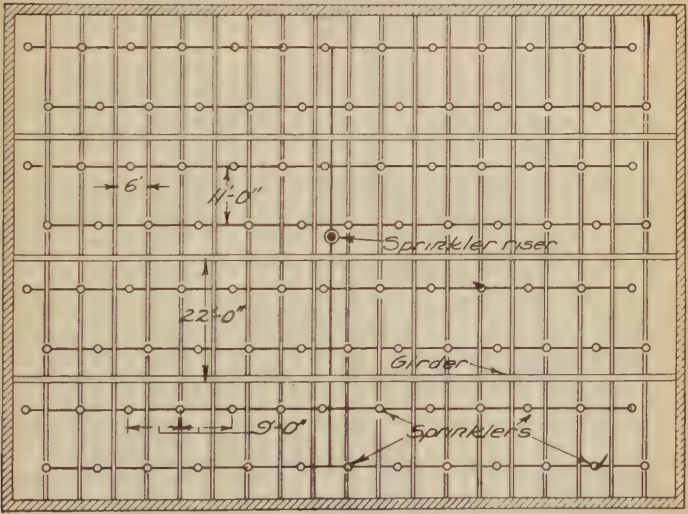
Fig. 104. Method of Spacing Sprinkler Heads
(6′–0″ × 20′–0″ Fire Proof Bays)

Authors' Note The sprinkler pipes are run at right angles to the joists and the distance between the sprinklers on each line must not exceed 8′, the distance between lines of sprinklers not to exceed 10′, this latter dimension being parallel with joists. The purpose of staggered spacing is to arrange sprinklers on alternate lines so that they will not discharge into the same joist channels, thus preventing the fire from spreading from one side of the roof to the other between joists.

It is impossible to obtain as effective sprinkler protection under open joist as under "mill" ceilings, the space between joists being to a large extent out of the reach of the water distributed by the sprinklers. Fire once reaching these spaces, while checked by the sprinklers, has to be extinguished by hand. Even under "mill" ceilings, a sprinkler, as customarily located and under 25 pounds pressure, will not spray the ceiling except for a space about 3 feet in diameter.

Owing to the fact that joisted construction needs close spacing, it is seldom advisable to allow the "exception" mentioned above. A compromise measure is to allow one line in every other bay, instead of every bay, where bays are from 10 to 11½ feet, this bringing the lines not over 8 feet apart.

(b) Sheathed or Plastered Ceilings—Under smooth finish, sheathed or plastered ceilings, in bays 6 to 12 feet wide (measurement to be taken from center to center of timber, girder or other projection or support forming the bay), one line of sprinklers shall be placed in center of each bay, and distance between the sprinklers on each line should not exceed the following: 8 feet in 12 foot bays; 9 feet in 11 foot bays; 10 feet in 6 to 10 foot bays. Bays in excess of 12 feet in width and less than 23 feet in width should contain at least two lines of sprinklers; bays 23 feet in width or over should have the lines therein not over 10 feet apart. In bays in excess of 12 feet in width not more than 100 square feet ceiling area should be allotted any one sprinkler.



Case D

FIG. 105. METHOD OF SPACING SPRINKLER HEADS
(6'–0" × 22'–0" Fire Proof Bays)

This rule shall not be interpreted to permit a spacing of more than 10 feet between sprinklers on a branch line.

19. Pitched Roofs—Under a pitched roof sloping more steeply than 1 foot in 3, sprinklers shall be located in peak of roof, and those on either side of peak spaced according to above requirements. Distance between sprinklers should be measured on a line parallel with roof. Where the roof meets the floor line, sprinklers should be placed not over 3½ feet from where roof timbers meet floor.

Sprinklers not more than 2½ feet distant each way from the peak of roof, measured on a line with the roof, may be used in lieu of sprinklers located in peak of roof as above.

Under saw-tooth roofs, end sprinklers on branch lines shall not be less than 1 foot nor more than 2½ feet from the peaks of these roofs.

Authors' Note—It is difficult properly to protect with sprinklers a room having a pitch roof, particularly where the roof meets or comes close to the floor line. Heavy wire netting should be used at such points to prevent storage near eaves or around sprinklers. This netting should be fastened about two feet from the inside of roof boards parallel to the roof line. Pitch roof should properly be removed and a flat mill roof substituted.

20. Fire-resistive Construction—The rules for slow-burning construction should apply as far as practicable. The rule may be modified, however, the intent being to arrange the spacing of sprinklers to protect the contents rather than the ceilings; but in no case shall the distance of a sprinkler on a line exceed 12 feet to a sprinkler on an adjoining line.

21. Unusual Construction—Special instructions should be obtained from Inspection Department having jurisdiction relative to location of sprinklers under floors and roofs of semi-mill, panel, or other unusual construction which may interfere with distribution of water, and for which provision is not hereinbefore made.

These types of construction are so varied that no absolute rules can be given to cover all cases.

"Semi-mill" is the term here applied to plank and timber construction with narrow bays generally less than 5 feet in width.

"Panel" construction is where the ceiling is divided by the timbers into panels or pockets. Narrow bay panels come under the head of "semi-mill" construction, and may usually be protected in the same way.

Sprinkler lines should usually run at right angles to the timbers, with heads staggered under alternate timbers, in alternate bays, or alternately under the timbers and in the bays, the arrangement depending on the width of the bay, the size of the timbers and the distance between supporting girders, as well as upon the occupancy and water pressure.

Ordinarily, where the timbers are not larger than 6 × 10 inches, the best distribution is obtained by placing the heads under the timbers.

The distance between lines will depend somewhat upon the distance between the girders supporting the timbers, the number of lines in these transverse bays being governed largely by the distance between the heads on the lines.

SECTION D—PIPE SIZES

22. General Schedule—In no case should the number of sprinklers on a given size pipe on one floor of one fire section exceed the following (see table).

SPRINKLER PIPE SIZES

Size of Pipe in Inches.	Maximum Number of Heads Allowed.			
	Present Standard 1905 to Date, 1–2–3 System.	Original N.F.P.A. Standard 1896 to 1905, 1–2–4 System.		Providence Steam and Gas Pipe Co. 1878 to 1896, 1–3–6 System.
		General.	Branches.	
¾	1	1	1	1
1	2	2	2	3
1¼	3	4	4	6
1½	5	8	6	10
2	10	16	8	18
2½	20	28	16	28
3	36	48	28	48
3½	55	78		78
4	80	110		115
5	140	150		150
6	200	200		200

Where practicable, it is desirable to arrange the piping so that the number of sprinklers on a branch line will not exceed eight.

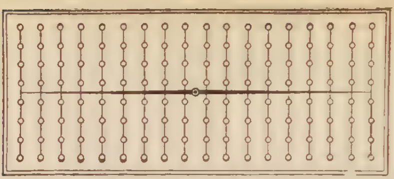
For Railway Car Houses see Section N.

Where feed mains supply branch lines of only two sprinklers each, the conditions approach those of long single lines. Such feeds should usually be centrally supplied where there are over eight or ten branch lines. Lines up to fourteen in number may be fed from end, provided that 2½-inch pipe does not supply more than sixteen sprinklers.

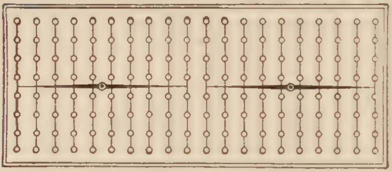
Buildings having slatted floors, or large unprotected floor openings without approved stops, should be treated as one room with reference to the pipe sizes, and the feed main should be of sufficient size to accommodate the number of sprinklers called for. Larger pipe sizes than called for in the schedule may be required wherever the construction or conditions introduce unusually long runs of pipe or many angles. Buildings with blind attics with small unprotected openings to floor below may be piped from the system on the ceiling of floor below, provided pipe size schedule is not overloaded on sizes 3 inches or under.

Authors' Note—The intent of the above is to regulate the number of sprinklers on a given sized pipe on one floor of a fire section. It is not intended to apply to feed mains or risers which may supply more than one floor or more than one fire section. For instance, a four-story building might need four hundred sprinklers; with a hundred on each floor this would require a five-inch riser.

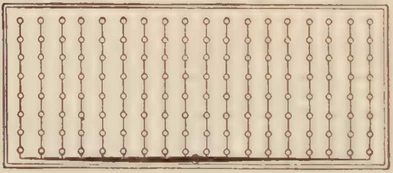
Where sprinklers are installed in an attic and where such sprinklers are supplied from the same piping which supplies sprinklers under the ceiling of the top story, the rules of some Inspection Departments require that every other head in the attic shall be sized in with the sprinklers in the story below. The Central Actuarial Bureau have issued the following schedule to cover this condition for pipe sizes up to and including 3 inch.



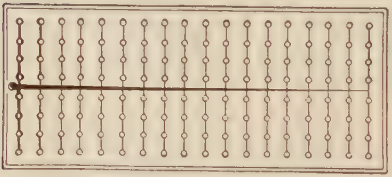
Case A. Center Central. (Best Method.)



Case B. Center Central. (2 Risers.)

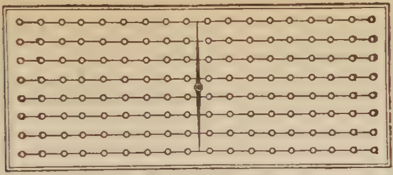


Case C. Side Central.

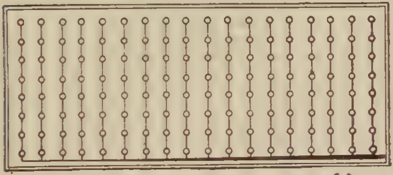


Case D. End Central.

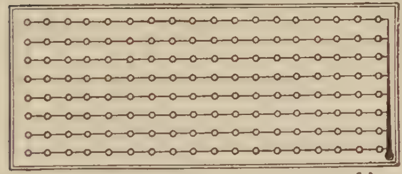
FIG. 106. VARIOUS ARRANGEMENTS OF FEED MAINS TO AUTOMATIC SPRINKLERS



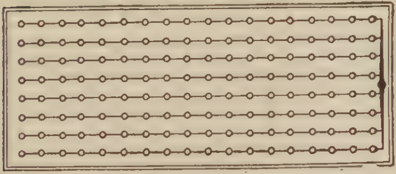
Case E. Across Center.



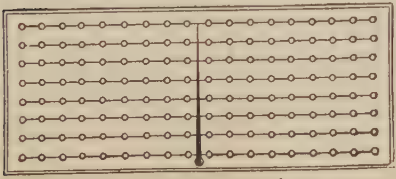
Case F. End Side. (Unapproved.)



Case G. Across End. (Unapproved.)



Case H. Center End. (Unapproved.)



Case I. Side Center Across.

FIG. 106. VARIOUS ARRANGEMENTS OF FEED MAINS TO AUTOMATIC SPRINKLERS.
∘ Shows a Sprinkler. ⊗ Shows a Riser.

Size of Pipe	Maximum No. of Sprinklers allowed
¾-inch	1
1 -inch	2
1¼-inch	4
1½-inch	7
2 -inch	14
2½-inch	28
3 -inch	48

In 1878 the Providence Steam & Gas Pipe Co., which for some years had been installing perforated pipes for fire protection, adopted a schedule, which is the basis for all automatic sprinkler pipe schedules (see table).

In time amendments were made locally so that there were many standards in various parts of the country. In 1806 a conference (out of which grew the National Fire Protection Association) formulated a schedule which until 1905 was the generally accepted standard for the stock insurance organizations. In this standard the small pipe sizes were somewhat increased which has been shown by experience to be desirable (see table). This standard also provided for a branch line schedule.

The old-fashioned "Parmelee," or "tree" arrangement of piping, viz., a pipe with short branches to one sprinkler on either side, shall be construed as coming under this rule.

This is penalizing the use of long branch lines, so that the tendency will be to arrange the piping in a manner affording less loss by friction.

In 1905 the pipe size schedules were again revised and the present schedule adopted. This still further increased the small pipe sizes and also permitted a considerable less number of sprinklers on the 2″ to 4″ sizes. It would appear that the present schedule is liberal as to pipe sizes and further change if any may tend towards a decrease rather than a further increase in required size of pipes.

In referring to the various pipe size schedules they are generally designated as the 1-3-6 schedule, 1-2-4 schedule, and the 1-2-3 schedule (present standard), from the number of sprinklers allowed on the ¾″, 1″ and 1¼″ pipe sizes.

SECTION E—FEED MAINS AND RISERS

23. Location of Risers—"Center central" or "side central" feed to sprinklers is recommended. The former is preferred, especially where there are over six sprinklers on a branch line. In high buildings, allowance must be made for frictional loss and sizes of risers increased accordingly. Risers should not be located close to windows, and should be properly protected from mechanical injury or a possible freezing.

Authors' Note—The object is to place all sprinklers near the larger sized supply pipe and thus allow the distribution of water from the various sprinklers to be more uniform. Various methods which have been used are shown in cases "a" to "i" in Fig. 106. Methods shown in cases "f," "g," and "h" are considered as unapproved. Methods shown in cases "e" and "i" would generally be undesirable because of the long branch lines. The same thing might be true of case "c" with average buildings. Case "a" shows the best method and one that is generally feasible

24. Supporting of Risers-Risers should be properly supported. In buildings of heavy construction and where riser is not supported at the ground level, floor plates or clamps and pipe couplings should be provided at the first (ground) floor level, and also at every fourth floor above same, where a building is over five stories in height, except that in buildings nine to ten stories high no floor plate nor coupling would be needed above the fifth floor.

This would call for such supports at the first (ground) and fifth floors in a building seven to ten stories high, and floor plates and couplings at the first (ground), fifth, and ninth floors in buildings eleven to fourteen stories high, etc. In buildings of light construction, additional supports will be needed.

Where risers are supported at the ground level, provide such supports at every fourth floor above same.

In lieu of floor plates and couplings as called for above, extra hangers near the risers and so arranged as to properly support the weight may be accepted.

Where sprinkler risers, or those from tanks, are in vertical shafts, they should be supported equivalent to the above.

Where risers, drains, heating pipes, etc., pass through cinder concrete, a sleeve or other suitable means should be provided to prevent corrosion. Neat cement or seven per cent. lime mortar around the pipe will protect same.

Authors' Note—There have been several breaks followed by serious water damage, owing to poorly supported risers or feed mains.

25. Size of Risers—There should be one or more separate risers in each building and in each section of the building divided by fire walls. Each riser should be of sufficient size to supply all the sprinklers on said riser on any one floor, as determined by the standard schedule of pipe sizes. If the conditions warrant, special permission will be granted allowing the sprinklers in a fire section of small area to be fed from the riser in another section.

Stair or other towers without approved stops between floors, if piped on independent riser, should be treated as one room with reference to pipe sizes, i.e., feed main should be of sufficient size to accommodate the total number of sprinklers.

Authors' Note—The sprinkler system was originally and is today largely planned on the assumption that there are no openings between floors, and that for a time the fire and heat will be confined where originating, allowing the control of the fire by the nearest sprinklers if at all.

26. Connections to Systems—All main water supplies should connect with sprinkler system at foot of riser, but systems with both pressure and gravity tank supplies, where air lock is liable to develop, shall have gravity tank discharge connected into dead riser 40 feet below the bottom of the pressure tank.

Exception: Where a gravity or pressure tank or both, constitute the only automatic source of water supply, special permission may be given to connect the tank or tanks with the sprinkler system at the top of the riser, provided lower level control to several fire sections is not required.

The connection between the wrought and cast pipe from underground main should preferably be flange and spigot pipe properly strapped together.

Where bell and spigot pipe is used, the wrought and cast pipes should be properly strapped together. A flanged connection should be used on the wrought pipe and not simply clamps with set-screws. (See Rule 101, on Clamps.) Straps or rods, if to be buried, should be protected against corrosion by painting with tar, asphaltum, or by other suitable means. Where practicable, connections should run underground to the foot of the riser; but in any event, the cast pipe should extend above ground, and no cinders or other corrosive material should be placed against either pipe. See rule 27.

Where there is but one fire area no underground pipe should ordinarily be required.

Note—The Sprinkler Committee recommended that where the discharge pipes are not changed in existing pressure and gravity tank equipments, the water line be raised to a point equal to 1.4 times the radius of the tank above the bottom and that the normal working air pressure be reduced to 60 pounds.

Authors' Note—The purpose of this rule is first, to have all water supplies connect to sprinkler system at one point, namely, base of feed pipe or risers, this so that a single valve may be located at this point controlling all water supplies. Furthermore, it is desirable to have this valve easily and

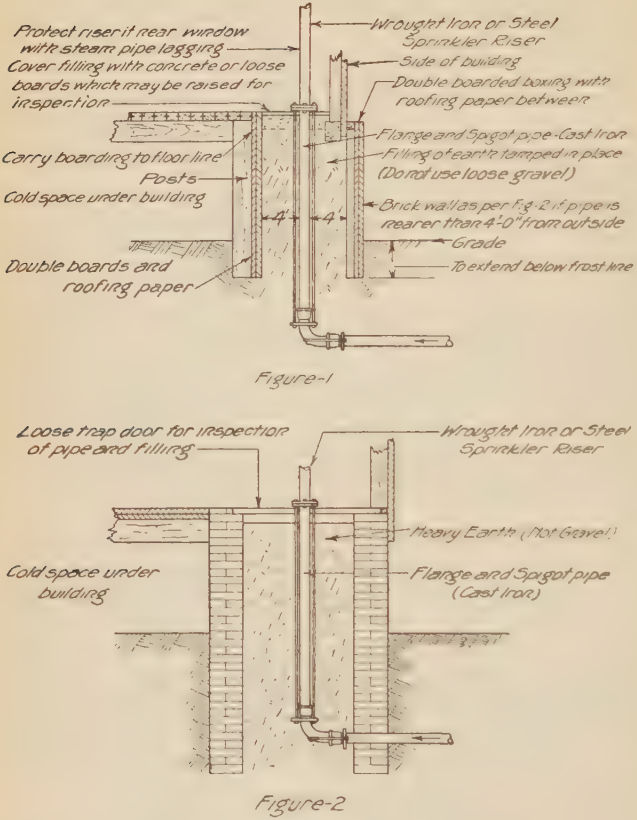
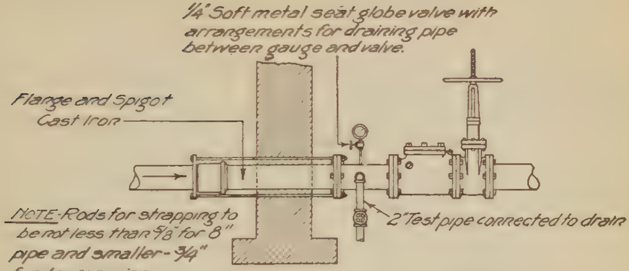
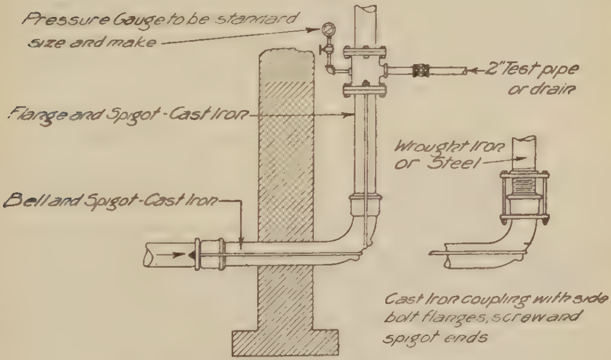

Protect riser if near window with steam pipe lagging
Cover filling with concrete or loose boards which may be raised for inspection
Carry boarding to floor line
Posts
Cold space under building
Double boards and roofing paper
Wrought Iron or Steel Sprinkler Riser
Side of building
Double boarded boxing with roofing paper between
Flange and Spigot pipe - Cast Iron
Filling of earth tamped in place (Do not use loose gravel)
Brick wall as per Fig-2 if pipe is nearer than 4'-0" from outside
Grade
To extend below frost line
4'
4'
Figure-1
Loose trap door for inspection of pipe and filling
Wrought Iron or Steel Sprinkler Riser
Heavy Earth (Not Gravel)
Cold space under building
Flange and Spigot pipe (Cast Iron)
Figure-2

Fig. 107. Protection of Risers Against Freezing.


¼" Soft metal seat globe valve with arrangements for draining pipe between gauge and valve.
Flange and Spigot Cast Iron
NOTE-Rods for strapping to be not less than ⅝" for 8" pipe and smaller-¾" for larger pipe.
2" Test pipe connected to drain

Test Pipe at City connection or other water supply
Especially serviceable with more than one City connection
Will also serve to test out Check Valve by closing the Water works or other outside valve, if any.


Pressure Gauge to be standard size and make
2" Test pipe or drain
Flange and Spigot-Cast Iron
Wrought Iron or Steel
Bell and Spigot-Cast Iron
Cast Iron coupling with side bolt flanges, screw and spigot ends

Test pipe where there is outside control
Also applicable to any other interior riser

Fig. 108. Methods of Strapping Piping.

quickly accessible which would more likely be the case if located in yard or basement than if on top floor.

Horizontal feeders to risers where inside of building and hung from floors should be as short as possible. Because of expense the tendency is to run this large pipe overhead rather than underground, thus increasing the chances of crippling the system.

27. Protection Against Frost—See Fig. 107. Where supply pipes or risers in low basements or low spaces under ground floors are exposed to frost, they should be properly protected. An acceptable method, especially where the space is over 18 inches high, is by an enclosure properly heated or filled with heavy earth or other suitable material, such as mineral wool or sawdust. Enclosure should extend below bottom of pipe and through the top flooring of ground floor. In severe climates, where space is filled, the enclosure should be of sufficient size to permit of a filling of not less than four (4) feet, all sides around the pipe. Enclosure should preferably be of brick, but may be of wood, and if the latter, should be at least double with tar-paper between. Where the space is not more than 18 inches high, the flooring of ground floor may be cut away and the space around the pipe enclosed according to either of the above methods, but the area may be reduced so that there will be not less than one (1) foot clear space all sides around the pipe, thus exposing pipe to the heated room above. Opening at floor level should not be covered except by a metal grid.

In any case where wood is used, it should be of a kind that will endure underground, and in addition should be treated with creosote or other acceptable preservative.

Care should be taken in laying the underground connection to extend it sufficiently far into the building to give the required spaces called for above, the pipe to be offset, if desired, at or above the floor level.

The laying of connections in raceways exposed to frost should be avoided, owing to the difficulty of protecting the pipe near the surface and in the space between the surface of the water and the floor of the building. Such connections, if they cannot be avoided, should go through the wall of the race below the frost line, and enter the building through the solid ground, and far enough back from the side of the race to avoid frost.

SECTION F—VALVES AND FITTINGS

28. Types of Valves to be Used—All valves on connections to water supplies and in supply pipes to sprinklers should be standard outside screw and yoke or other standard indicator pattern.

Underground gate valves of standard pattern equipped with standard indicator posts fulfill this rule.

Drip and/or test valves should be of a standard type.

Check valves should be of a standard straight-way pattern, and installed in horizontal pipe, unless suitably designed for vertical position.

Authors' Note—Globe gate or combination gate and check valves are not approved. Check valves with leather or rubber seats or discs are not recommended, the metal to metal pattern being generally considered to be the most reliable.

29. Valves in Connection to Water Supply—Check valves shall be installed in all sources of supply, except where cushion tanks are used in connection with automatic fire pumps, in which case no check valve should be required in the cushion tank connection. Gate valves shall be required on each side of each check valve, except as noted. No gate valves shall be installed in Fire Department connections. Where gravity tank is located on a tower in yard, valve on tank side of check should be of the O. S. & Y. type; other valve may of O. S. & Y. or P. I. V. pattern. Where gravity tank is located on top of building, these valves may be of the O. S. & Y. type. Where city main serves as one source of supply, control gate on each side of check should also be required; i.e., city gate and O. S. & Y. or Post Indicator on the system side of city connection. Where a pressure tank serves as one source of supply and the other supply is either a connection to city main or fire pump, an O. S. & Y. gate should be required on each side of pressure tank check. Where gravity and pressure tanks are installed as the only source of supply, control gates should be required on each side of gravity tank check only; gate valve in pressure tank connection shall be installed between check and tank, and shall be flanged to pressure tank nozzle. Where gravity tanks are located above roofs of buildings, all fittings inside of the buildings except the drain tee, shall be under control of a gate valve. All Fire Department connections shall be connected with systems on the discharge side of all city control gates. The check valve should be located as far as possible from source of supply, preferably underground.

30. Check or Gate Valve on Pump or Tank Discharge—When a pump, not located in a non-combustible pump house, or exposed to danger from fire or falling walls, or a tank discharges into a yard main fed by another supply, a check valve or post gate valve should be placed in this discharge pipe at a safe distance outside the building, underground.

Check valves on tank or pump connections may be placed inside of buildings when located underground and at a safe distance from the tank riser or pump, except in cases where the building is entirely of one fire area, in which cases it should ordinarily be considered satisfactory to locate the check valve overhead in the lowest level.

31. Valves in Supply Pipes to Sprinklers—Each system shall be provided with a gate valve so located as to control all sources of water supply except that from fire department connections. All gate valves controlling water supplies for sprinklers should be located where readily accessible.

Floor valves may be required in special cases where area or height or number of tenants is excessive both in manufacturing and mercantile buildings, or where contents are more than ordinarily susceptible to damage such as in department stores and drug stocks.

When floor valves are used it is desirable to locate them so that they may be readily accessible in case of fire, as in stair towers, etc.

Where valves are not within easy access from ground or floor level, permanent ladders, clamped treads on risers, chains and wheels, or other means satisfactory to the Inspection Department having jurisdiction, should be provided.

Authors' Note—To prevent water damage it is necessary to be able quickly to shut off water supply. The system should, therefore, be so arranged that one gate valve controls all supplies and this gate valve should be always accessible.

It will be noted, that no provision is made in the rules for auxiliary gate valves, such as floor valves or valves controlling small sections. In some classes of risks such valves may be desirable or perhaps even necessary but generally the fewer valves the better, that there may be less chance of a valve being closed accidentally or otherwise. A multiplicity of valves leads to complications. Closed gate valves are the greatest menace to sprinkler protection and, while the danger of a closed gate valve may not be in direct proportion to the number of valves, it is nevertheless to a considerable degree influenced by this factor. Even with stocks of goods easily damaged by water, it is generally better to have one valve controlling all of the sprinklers in the building rather than valves on each floor. Experience has shown that the simpler the system and the fewer valves, the less danger of the system being out of commission, and, furthermore, the system is easily understood and there is less danger of shutting the wrong valve after the fire is out. The best arrangement is undoubtedly that of a single post gate valve outside controlling all the sprinklers in the building with no inside gates.

All gate valves controlling water supplies to sprinklers should be easily accessible. This means keeping stock or goods away from the valve and having an open unobstructed passage. Furthermore, if valve is located above the reach of an ordinary person a stationary ladder should be provided.

Gate valves should have signs and labels so as clearly to designate the section or water supplies which they control.

32. Indicator Posts for Gate Valves—Where sprinklers are supplied from yard main, place, if possible, a standard outside post indicator gate valve in connecting pipe at safe distance from building.

Post indicator valves should, if possible, be located not less than 40 feet from buildings; but where necessary to place a valve close to a building, it should be located between windows or at a blank part of wall.

Authors' Note—The outside post gate is in many instances the best and only necessary water supply control for sprinklers. While in many cases an inside gate valve is installed in addition to the post gate, this increases the chances for water being shut off accidentally and furthermore in such cases the less accessible inside valve is generally closed and in case of fire it may be impossible to reach valve and turn on the water.

Outside control for sprinklers in various fire sections is of great value as it allows the shutting off of sprinklers in one section and maintaining the protection in the other sections.

Many of the older types of post indicators are defective, some improvements found in the standard type being as follows: Porcelain bushed drips; rods, securely fastened to valve; frost-proof case; large hand wheel with provisions for fastening open by chain or leather strap and padlock; provisions for oiling, also, of course, reliable mechanism for moving the target or indicator. It is noted that sometimes a right-hand indicator will be placed on a left-hand gate or vice versa. Also rods become unfastened so that gate remains closed while indicator shows open.

33. Pit for Underground Check Valves—Where not in pits, the location should be properly marked by some permanent marking. Where in pits, the pits should conform to the National Fire Protection Association standard, and should be of ample size to permit of easy access to the valve for examination and repairs.

Authors' Note—Owing to the expense of pits it is questionable if they should always be required. It is, however, of vital importance to be able definitely to locate the check valve as for instance by a permanent mark on building wall. Check valves are sometimes found obstructed so that they cannot be closed, and the object for which they are installed is temporarily defeated. They need to be cleaned and repaired occasionally, and for this reason should be located where easy of access.

34. Securing and Marking—All gate valves in supply pipes to automatic sprinklers, whether or not of indicator or post pattern, should be kept secured open in a standard manner.

All control gates shall be plainly marked indicating the section or portion controlled.

Authors' Note—A large proportion of so-called sprinkler failures are due to closed gate valves. A properly maintained system of strapping or sealing valves is the best safeguard against closed valves. A light leather strap with a ring riveted at each end, the rings being padlocked together, forms a simple and effective method. The strap can be easily cut if necessary. Padlocks should have common keys kept by responsible parties, such as engineer, or whoever is in charge of fire appliances. Where valves are to be used only in case of repairs, and do not come under the head of essential sprinkler controlling valves, they should be locked and chained open rather than strapped, as an additional safeguard against tampering. Such valves would include city inlet valves, valves under tanks, valves at bottom of risers where there is a post gate or similar outside control, branch valves, and valves in pump suction. See also Supervision and Care of Valves, page 483.

35. Fittings—Extra heavy fittings should be employed where the normal pressure in the pipe system exceeds one hundred and fifty pounds.

All fittings and pipes shall have threads cut to standard, and care should be taken that the pipe does not extend into fitting sufficiently to reduce the waterway.

Long turn fittings shall be required for all supply mains 2½ inches and larger except where there is a reduction of 1 inch or more in size. Long turn fittings in risers shall be flanged at one end.

Couplings—Couplings shall not be used except where it is practically unavoidable.

The use of any considerable number of couplings in an equipment is considered as *prima facie* evidence of poor workmanship.

Reducers—A one-piece reducing fitting of good design shall be used wherever a change is made in the size of pipe. Bushings shall not be used for reducting the size of the openings of fittings.

Authors' Note—Long turn fittings are more needed in small than large sizes as far as loss by friction is concerned, but are not required in either. Their use in many places, as at the riser, gives the equipment a better appearance.

36. Hangers—Hangers shall be of an approved type and either round wrought-iron "U" (factory made and bent hot), malleable cast-iron ring clip, or other adjustable patterns.

Wrought-iron hangers are preferable to cast-iron, and "U" hangers are for this reason best where their use is possible.

Flat-iron "U" hangers may be accepted, provided the thickness of the metal be in no case less than 3/16-inch, and of sufficient width to allow plenty of metal each side of the screw holes.

Srews and Rods—Wood screws for adjustable clip hangers should not be smaller than No. 17, and must penetrate ceiling beam or joist at least 1¼ inches. For 2-inch pipes and smaller two screws should be used, and for larger pipes four screws should be used.

The size of rod and screws for hangers should be as given in the following tables:

Size of Pipe	Size of U. Rod	Size of Single Rod if Threaded	Size of Drive Screws	Size of Coach Screws
¾″ to 2″	5/16″	⅜″	No. 16 x 2″	
2½″	⅜″	½″		⅜ x 2½″
3″	⅜″	½″		⅜ x 2½″
3½″	7/16″	½″		⅜ x 2½″
4″	7/16″	⅝″		½ x 3″
5″	9/16″	⅝″		½ x 3″
6″	⅝″	¾″		½ x 3″
8″	¾″	⅞″		⅝ x 3″

Drive screws should be used only in a horizontal position as in the side of a beam.

Screws in the side of a timber or joist should not be less than 2½ inches from the lower edge, when supporting branch lines. A greater distance is desirable for larger pipes.

Position of Hangers—Hangers should not be near enough to sprinklers to obstruct distribution of water. Ordinarily, they should not be nearer than 12 inches from sprinkler, except in the case of round iron hangers, where a space of not less than 3 inches may be permitted under ceilings of "fire-resistive" and "slow-burning" construction.

The ¾-inch pipe at the end of all branch lines when over 6 feet in length shall have two hangers.

For concrete construction: Where expansion bolts are used, they should be of a type satisfactory to the Inspection Department having jurisdiction, and if possible installed in a horizontal position.

Where pipes are run through concrete beams, the sleeves should be large enough to accommodate pipe at least two sizes larger than it is intended to install.

37. Drip Pipes—Drip or drain pipes should be provided to drain off all parts of the system. Drip or drain pipes at the main risers shall not be smaller than 2 inches, and where such drain pipes are buried underground, galvanized iron pipes should be used, and when exposed to the weather should be fitted with hood or down-turned elbow to prevent stoppage with ice.

Drip pipes shall be so arranged as not to expose any part of the sprinkler system to frost, and so connected, either by check valves or other means, that they will not overflow domestic service or other connections there may be to the same sewer or drain.

Drips for small sections shut off in winter shall be located in a warm room or below frost, so as to drain all portions of pipe where freezing can occur.

Drain, drip, or draw-off pipes shall not terminate in blind spaces under the buildings. The water from these washes the soil away, exposing the supply pipe and may undermine the structure protecting the pipe.

Cold air enters draw-off pipes and may cause freezing of the valves.

All drips should have at least 4 feet of pipe beyond valve exposed in the warm room.

Fig. 120 shows ball drip, useful in a number of ways in connection with sprinkler systems.

See also Section G, Alarm System.

Authors' Note—Many drip pipes are found "frozen up" during cold weather. Cause: Leaky or partly closed valve, pipe improperly pitched. Result: Pipe stopped up, no way quickly to drain system.

38. Drainage—All sprinkler pipe and fittings shall be so installed that they can be thoroughly drained, and, where practicable, all piping should be arranged to drain at the main drips. On wet-pipe systems the horizontal branch pipes shall be pitched not less than ¼-inch in 10 feet. (See also Section H, Rule 48.)

All trapped heads in excess of 20 on wet systems will require a separate drain valve and drain connection; 20 or less heads will require the installation of composition drain plugs. Limit the extra drips to as small a number as possible.

39. Test Pipes—*System*—On wet systems a test pipe of not less than ¾ inch in diameter shall be connected directly with each system (but shall be connected to a pipe of not less than 2½ inches diameter) in upper story and arranged to discharge, through a ½-inch brass outlet, preferably to a point where it can readily be seen. With long runs or many angles, size of test pipe should be increased to 1 inch or larger. Controlling valve should be located at a sufficient distance from where the test pipe passes through the wall of the building so as to reduce to a minimum the chance of freezing of water in test pipe.

Drain test connection shall be made to a down spout or drain line. The practice of discharging test water in alleys or other places where damage to property is possible is not permissible.

Water Supplies—It is very essential that either drains or test pipes should be provided so that proper flowing tests may be made to determine if the water supplies and/or the connections from yard mains to inside of buildings are in order. Any such drain or test pipe should be not less than 2 inches in size, and so installed that the controlling valves may be opened wide for a sufficient time to assure a proper test without overflowing any service connections there may be to the same drain, or cause any water damage. A pressure gauge should be installed in each case; connection for it should not be less than ¼-inch in size, controlled by a valve with arrangements for draining, and located on the main pipe and not on the drain or test pipe. On a wet system, where the controlling valves and drains may be located in a detached pit or valve house, test pipes should be provided inside of the buildings on the various connections to the sprinkler system. The Inspection Department having jurisdiction should determine the method to be used in each case. See illustrations for various types of test pipes, and also Rule 40.

Dry-pipe Systems—See Section H, Rule 56.

40. Pressure Gauges—A standard make, 4½-inch dial, spring pressure gauge shall be connected with the discharge pipe from each water supply, including each connecting pipe from public waterworks, and also as follows:

In each sprinkler system above and below the alarm check or dry-pipe valve.

At the air pump supplying the pressure tank.

At the pressure tank.

In each independent pipe from air supply to dry-pipe systems.

At test pipes as above, Rule 39.

Gauges shall have a maximum limit equivalent to twice the normal working pressure where installed. Should also be connected direct with riser, but with sufficient clearance to permit of easy removal, connection being tapped into drain tee, preferably opposite the drainpipe, but not on drainpipe. Gauges should be located in a suitable place and where water will not freeze. Each should be controlled by a valve with arrangement to drain. A plugged outlet should be located between each valve and gauge, for the purpose of installing the inspector's gauge, size to be not less than as noted in Rule 39.

This rule shall not apply to the discharge pipes from gravity and pressure tanks.

SECTION G—ALARM SYSTEMS

Rules 41 to 46 inclusive will be found reproduced in Chapter 31 Alarm Valves for Automatic Sprinkler Systems.

SECTION H—DRY-PIPE SYSTEM AND FITTINGS

Rules 47 to 60 inclusive will be found reproduced in Chapter 32 on Dry Valves for Automatic Sprinkler Systems.

SECTION I—WATER SUPPLIES

61. Double Supply—For a standard equipment two independent supplies are required. At least one of the supplies should be automatic and one capable of furnishing water under heavy pressure. The choice of water supplies for each equipment should be determined by the Inspection Department having jurisdiction.

Authors' Note—For general discussion of water supplies and for detailed information regarding the various types of supplies covered in Section I, see Chapter 26 on Water Supply for Private Protection.

62. Public Water (except high pressure systems; also applicable to private reservoir and standpipe systems)—One or more connections from a reliable public water system of good pressure and adequate capacity furnishes an ideal "primary supply." A high static water pressure should not, however, be a criterion by which the efficiency of the supply is determined. The supply should give not less than 25 pounds static pressure at all hours of the day at highest line of sprinklers, and also be satisfactory to the Inspection Department having jurisdiction in its ability to maintain 10 pounds pressure at highest sprinklers, with the water flowing through the number of sprinklers judged liable to be opened by a fire at any one time. Street mains should be of ample size, in no case smaller than 6 inches. Dead end mains should be avoided if possible by arranging main to be fed both ways. No pressure regulating valve should be used in water supply for sprinklers, except by special permission of Inspection Department having jurisdiction, and where meters are used they should be of a standard type.

Where connections are made from public waterworks systems, it is often desirable to have double check valves. Only check valves of special design and standardized for this purpose should be used.

See also Section E, Rule 26.

Connections to public waterworks systems should, where feasible, be controlled by post indicator valves of a standard type and located not less than 40 feet from the buildings protected; or, if this cannot be done, placed where they will be readily accessible in case of fire and not liable to injury. See Rules 26, 27, 29, 31, 32, and 103. Where post indicator valves cannot readily be used, as in a city block, underground gates should conform to the above as far as possible and their locations and direction to open be plainly marked on the buildings.

Connections for domestic or standpipe use over 2 inches in size should conform to the above.

All post indicator valves should be plainly marked with the service they control. .

For the construction and installation of the following devices, see special pamphlets issued by the National Board of Fire Underwriters:

Steam Fire Pumps.
Rotary Fire Pumps.
Centrifugal Fire Pumps.
Gasoline Fire Pumps.
Tanks and Supports.

63. Pumps—A well-located fire pump is, under most conditions, the most satisfactory source of the "secondary supply," as with ample water supply it is capable of maintaining a high pressure over a long period of time.

The capacity of the pumping plant, the kind of pump and its source of water supply, should be determined by conditions, and should be the subject of special consideration in each case by the Inspection Department having jurisdiction. The capacity of pump should never be less than 500 gallons per minute when it supplies sprinklers only, and not less than 750 gallons when it supplies hydrants also.

64. Tanks—*Gravity*—The capacity and elevation should be determined by the Inspection Department having jurisdiction; but where a tank is also drawn upon for hose streams it should not be of less than 30,000 gallons capacity, and should preferably be installed with the bottom not less than 75 feet above the yard level. In any case the bottom of the tank should be at least 20 feet above the highest sprinklers.

Tanks—*Pressure*—Capacity of tank should be specified by the Inspection Department having jurisdiction, but should be not less than 4,500 gallons total capacity, except by special permission, and tank should not be located below the upper story of building, and should be used as a supply to automatic sprinklers and hand hose only. (See Section K, Rule 79.)

65. Penstocks or Flumes—Where connections are made from these, either as a direct supply to automatic sprinklers or as a suction for fire pumps, they should be arranged to avoid mud and sediment. Connection should also be provided with double removable screens installed to the requirements of the Inspection Department having jurisdiction. Where double connections are made from rivers or lakes they should be provided with removable screens similar to those for pump suction.

66. Size of Connection—Connection from water supply or main pipe system to sprinkler riser should be equal to or larger in size than the riser. Connections for domestic use should not be taken from the fire system. See also Section E, Rule 26, and Underground Pipes, Section M.

SECTION J—FIRE DEPARTMENT CONNECTIONS

Rules 67 to 72 inclusive will be found reproduced under heading of Fire Department Connections in Chapter 26 on Water Supply for Private Protection.

SECTION K—MISCELLANEOUS RULES

73. Circulation in Pipes—Circulation of water in sprinkler pipes is very objectionable, owing to greatly increased corrosion, deposit of sediment, and condensation drip from pipes; sprinkler pipes not to be used in any way for domestic service.

74. Painting, Whitewashing, or Bronzing—Where pipes are painted, whitewashed or bronzed for appearance, the moving parts of sprinkler heads should not be so coated. The heads should be carefully protected with small paper bags when building is being decorated, which bags should be removed immediately upon completion of decorations.

75. Protection of Pipes and Sprinklers Against Corrosion—In places where chemical fumes or much moisture is present, sprinkler pipes, hangers and heads should be protected against corrosion, method to be determined by the Inspection Department having jurisdiction; but the following are recommended:

Protection of Pipes—Where subject to corrosive influences, sprinkler piping and fittings should be thoroughly protected.

In some places it will be satisfactory to paint annually with red lead and linseed oil paint, this usually giving sufficient protection when exposed to moisture only.

When chemical fumes are present, the piping should be coated with some good chemical-resistive paint which should be in itself chemically inert and at the same time form a good bond with the exterior of the pipe. Extra care should be used in applying such paint; it should not be applied on a damp day, nor upon damp or cold surfaces; the piping should be thoroughly cleaned of all scale and dirt (the use of a stiff wire bristle brush is good for this), grease and oil; the paint should be kept thoroughly stirred and well applied, and after drying thoroughly a second coat should be applied. Two coats are usually better than more.

In some extremely exposed cases the piping has been protected by painting it with graphite paint and wrapping it with rubberized tape (such as the trimmings from rubber and canvas belts), after which the whole is given another coating of graphite paint. Cases have been known of piping protected in this way showing absolutely no sign of corrosion after six years of extremely severe exposure.

The use of galvanized piping is not very satisfactory; the cutting of the threads on the pipe removes the protective coating near the fittings where the pipe is, of course, the weakest, and further, the zinc forming the protective coating furnishes little protection against a great many corrosive vapors found in commercial practice.

Protection of Sprinklers—The manufacturers of standardized sprinklers can furnish heads specially protected against corrosion, and these should be used wherever sprinklers are exposed to corrosion. At the present time two types of sprinklers are available, one being a sprinkler with a glass cover, hermetically sealed, and the other being a head coated with a corrosion-resisting compound. Care should be taken in screwing the sprinkler into the fitting not to injure this protection, otherwise its effectiveness is destroyed.

Authors' Note—See also section on "Corrosion" in Chapter 29.

76. Alterations—It is not permitted to change, plug up or remove the fittings pertaining to dry-pipe valve, pressure tanks, pumps, gauges, etc. If such fittings leak or become deranged, they are to be put in order.

77. Extra Sprinkler Heads—There should be maintained on the premises a supply of extra sprinklers (never less than six), to promptly replace any fused or in any way injured.

Sprinklers should be of the various degrees that may be used in the risk.

78. Use of High Degree or Hard Sprinklers—High degree sprinklers should be used only when absolutely necessary and Inspection Department having jurisdiction should be consulted in each instance. When used, the following table should be referred to:

For ceiling temperature exceeding 100 degrees but not 150 degrees, install 212 degree heads.
For ceiling temperatures exceeding 150 degrees but not 225 degrees, install 286 degree heads.
For ceiling temperatures in excess of 225 degrees, install 360 degree heads.

Ordinary degree sprinklers should be substituted for high degree sprinklers where the latter are made unnecessary by cnange in occupancy.

Authors' Note—See also High Test Sprinklers in Chapter 29.

79. Hand Hose Connections—Hand hose, to be used for fire purposes only, may be attached to sprinkler pipes within a room under the following restrictions:

Pipe nipple and hose valve should be 1 inch.
Hose to be 1½ inches or 1¼ inches.
Nozzle should not be larger than ½ inch.
Hose should not be connected to any sprinkler pipe smaller than 2½ inches and never attached to a dry-pipe system.

Authors' Note—See also section on "Standpipes" in Chapter 28.

80. Concealed Pipe Systems—Concealed piping is prohibited except when the Inspection Department having jurisdiction gives consent. When installation is permitted, it should be in accordance with the following:

a—Pipe should be of standard weight wrought-iron or steel, painted with two coats of good protective paint, one before and one after installation.
b—Should be placed in properly constructed ducts or thoroughly encased in Portland cement or equivalent. In no case shall the pipe system be installed so as to form a part of the floor arch reinforcement.
c—When installed in the concealed space between the floor arch and ceiling, pipe should be supported by standard hangers, and all pipe, fittings, and hangers should be given two coats of good protective paint.

81. Tests After Installation—All systems should be tested at not less than 150 pounds pressure for 2 hours, or at 50 pounds in excess of the normal pressure when the normal pressure is in excess of 100 pounds. Emergency tests of dry-pipe systems, under at least 60 pounds air pressure, should be made at seasons of the year which will not permit testing out under water pressure.

Piping between check valve in fire department inlet pipe and outside connection should be tested same as balance of system.

Brine or other corrosive chemicals should not be used for testing systems.

To prevent the possibility of serious water damage in case of a break, pressure should be maintained by a small pump, the main controlling gate being meanwhile kept shut.

In the case of dry systems with differential type or dry-pipe valve, the valve should be held off its seat during the test to prevent injuring the valve.

In dry systems an air pressure of 40 pounds should be pumped up, allowed to stand 24 hours, and all leaks stopped which allow a loss of pressure of over 1½ pounds for the 24 hours.

A working test of dry-pipe valve should be made, if possible, before acceptance.

All tests should be made by contractor in presence of inspector of Inspection Department having jurisdiction.

82. Relief Valves or Air Chambers—Where connections are made from public mains, subject to severe water hammer (especially where pressure is in excess of 100 pounds), it is advisable to provide a relief valve, properly connected to a drain; or an air chamber in the connection. If an air chamber is used, it should be located close to where the pipe comes through wall, and back of all other valves, and at right angle to other valves, so as to take the full force of water hammer.

Air chambers shall have a capacity of not less than 4 cubic feet, shall be controlled by an O. S. & Y. gate valve and shall be provided with a drain at the bottom. If an air vent is deemed desirable by the Inspection Department having jurisdiction, it shall consist only of a plugged outlet.

83. Guards—Where guards are necessary, only those of a standard type shall be used.

84. Preliminary Inspection of Sprinkler Equipments—Before asking final approval of an automatic sprinkler equipment by the Inspection Department having jurisdiction, the installing company should furnish a written statement, countersigned by the property owner to the effect that the work has been completed in accordance with the approved specifications and plans. The object is to secure a reasonable amount of supervision of the equipment by the assured as the work progresses, a larger knowledge on their part of its functions and proper maintenance, and also to prevent needless waste of time of the Inspection Department. Inspection Department having jurisdiction should furnish the necessary blanks for the above purpose.

SECTION L—OPEN SPRINKLERS

Rules 85 to 95 inclusive will be found reproduced in Chapter 34 on Open Sprinklers.

SECTION M—UNDERGROUND PIPES AND FITTINGS

96. Weights—Should not be less than those specified in the following table, where the normal pressures do not exceed 125 pounds. Where the normal pressures are in excess of 125 pounds heavier piping should be used:

Pipe	Weight per ft. Including Sockets
4 inches	23.0 pounds
6 inches	35.8 pounds
8 inches	52.1 pounds
10 inches	70.8 pounds
12 inches	91.7 pounds
14 inches	116.7 pounds
16 inches	143.8 pounds

Pipe should be made in accordance with the essential features of the "Standard Specifications for Cast-Iron Pipe and Special Castings," adopted by the American Water Works Association, May 12, 1908. The inspector referred to in the Specifications should preferably be a representative of an independent inspection bureau making a business of examinations and tests of pipe of this character. In cases where the amount of pipe to be installed does not warrant the expense involved in a special examination, a certificate from the manufacturer, stating that the pipe has been made and tested as required, may be accepted by Inspection Department having jurisdiction, to whom the matter should be referred in advance of closing the contract.

Authors' Note—For further discussion of Underground Piping see Chapter 27 on Outside Private Protection.

97. Hydrant Main—See page 393, paragraph 10.

98. For Pipes Extending to a Dead End—See page 393, paragraph 11.

99. For Loop Systems—See page 393, paragraph 12.

100. Rules for Laying Cast Iron Mains. Depth of Earth Cover—See page 397, paragraph 18.

101. Care in Laying—See page 397, paragraph 19.

102. Location and Setting Hydrants—See page 403, paragraphs 43 and 44.

103. Valves—Every connection from a yard main to a building should be provided with a post indicator valve of a standard type and the name of the service controlled should be clearly stenciled on the valve.

When surroundings are such that the indicator post will interfere with the passing of teams or cars, the best practice is to use a valve of the outside screw and yoke pattern placed in a pit built in accordance with the National Board of Fire Underwriters' Regulations. (See special pamphlet on Tanks.) A wrench or crow-foot with long handle should be provided for each valve, and kept in the pit where it can be reached from the yard level. The location of the valve should be clearly marked on neighboring buildings, and the cover of the pit should be kept at all times free from dirt and snow.

Large yard systems should have sectional controlling valves, and a valve should be provided on each bank where a main crosses water.

104. Testing—See page 398, paragraph 32.

SECTION N—RAILWAY CAR HOUSES

Note: The foregoing rules are to be observed in protecting this class of property, and in addition thereto the special features as herein recommended are to apply.

In car houses of fire-resistive construction, with all steel work protected in accordance with the requirements of the N. B. F. U., of a height not in excess of 25 feet, and with areas not in excess of 20,000 square feet, aisle line sprinklers or ceiling sprinklers, but not both, may be modified or eliminated by the Inspection Department having jurisdiction.

105. Ceiling Curtains—Permanent ceiling curtains are recommended in buildings having a height of over 25 feet from floor to ceiling. These curtains may be constructed of rigidly supported non-combustible material, or of not less than 1-inch tongue and grooved boards, coated on both sides with standard fire-retarding paint; curtains to sub divide ceiling into pocket areas not exceeding 5,000 square feet each, and to be of a depth from ceiling to trolley wire. Inspection Department having jurisdiction should be consulted as regards the specific location of these curtains.

Authors' Note—One commendable ceiling curtain plan that has been used rather extensively involves the construction of non-combustible curtains carried down to a point just above the aisle lines. The aisle line sprinklers are attached to these curtains, and the combination is very definite guarantee against fire passing the aisle sprinklers.

106. Aisle Sprinklers.

a—In addition to the regular ceiling installation, sprinklers shall be placed on both sides of each track, in an upright position, on horizontal pipe lines parallel with tracks, and shall be so located that water will spray directly into cars through side windows of car bodies; the sprinklers must be at such a height that their deflectors will be from two to four inches below the upper sash rail of car windows.

b—When the distance between sides of cars on adjacent tracks does not exceed 4 feet, one line of sprinklers shall be placed in the center of each aisle between tracks.

c—When the distance between sides of cars on adjacent tracks exceeds 4 feet, two lines of sprinklers must be installed. Sprinklers shall not be placed less than 6 inches nor more than 12 inches from the sides of cars to be protected.

d—When the distance between the sides of cars on adjacent tracks is less than 12 inches, or where aisle lines in accordance with this section may not be practicable, as at curves, switches, transfer tables, car elevators, repair, and paint shops, special instructions from Inspection Department having jurisdiction should be obtained as regards installing raised or altered lines.

e—Sprinklers must be placed between cars and partitions, division or outer walls, not less than 6 inches nor more than 12 inches from the sides of cars to be protected.

f—Distance between sprinklers on aisle lines shall not exceed 8 feet.

g—The standard pipe schedule shall govern installation of aisle lines, except that no pipe smaller than one inch may be used.

h—Sprinklers on all aisle lines shall be staggered spaced.

107. Supply Mains to Aisle Sprinklers.

a—Ceiling and aisle sprinklers shall be installed upon separate dry valves or alarm valves.

b—In small car houses or sections of an area not great enough to require at least two dry valves, ceiling and aisle lines may be installed, supplied by one dry valve, in which case separate connections are to be taken from above and close to the dry pipe valve, and shut-off valves shall be provided for ceiling and aisle systems, so arranged that either may be controlled independently.

c—Aisle lines must not be supported by nor connected to ceiling sprinkler piping. Special hangers or supports must be provided that aisle lines may be rigidly secure.

d—Troughing shall be installed over trolley wires in such a manner as to preclude the possibility of a short circuit being caused, between grounded metal work and trolley wire, by the trolley pole.

108. Pits and Under Floor Space—Where the under floor space does not communicate with the pits, is tightly enclosed, and is not used for any purpose, sprinklers may be omitted in such floor space by special consent, in each instance, of the Inspection Department having jurisdiction.

CHAPTER 31

ALARM VALVES FOR AUTOMATIC SPRINKLER SYSTEMS

1. The value of a reliable water flow alarm valve attached to an automatic sprinkler system can hardly be over-estimated. The records show that the sprinklers alone fail to extinguish about one-third of all fires occurring in plants under sprinkler protection, and in these cases it is obvious that the water flow alarm has an important function, namely that of summoning persons to the scene of the fire. In those cases where sprinklers succeed in extinguishing fires, it is necessary that notification of the flowing of water be given in order that valves may be shut and unnecessary water damage avoided. The signal from a water flow alarm valve may be the first notification to persons of a fire in a building, and be instrumental in causing a prompt exit by those not delegated to the duty of fighting the fire.

2. An automatic sprinkler system with a reliable water flow alarm service connected therewith performs the function of the ordinary sprinkler system and of a special thermostat system. The cost of a complete system of thermostats is far greater than the additional cost of providing alarm facilities on a sprinkler system, and, speaking generally, the sprinkler head is a more reliable device than the thermostat.

3. The records contain many instances of exceedingly heavy water damage owing to lack of sprinkler alarm equipment or of competent supervision by watchmen, and consequently one of the ordinary requirements for "sprinkler leakage" insurance is that there shall be an alarm system. Underwriters, on the whole, however, have not paid the attention to water flow alarm valves which their importance is believed to warrant.

TYPES OF VALVES.

4. Figures 109 to 118 show modern types of alarm valves from which excellent service is being secured. There have, however, in the past, been a considerable number of unreliable types of alarm valves, notably those having an outside lever or protruding stem or pin to which motion is imparted by the movement of a disc or flapper inside of the check valve body.

LOCAL ALARM SERVICE.

5. Water flow alarm valves, as ordinarily installed, merely give local alarms in case of flow of water through the alarm check. Figures in this chapter illustrate the manner in which alarm checks are installed, retardation chambers connected, and electric circuit-closing and water motor alarm-giving devices attached.

6. Alarm Connections—The general practice very properly has been to make use both of electric alarms and of water motor driven mechanical alarms so as to have duplicate service.

7. Alarm connections should preferably have the square-headed cock type of valve with wrench permanently attached. Handle of wrench can be slotted so that wrench can readily be strapped or wired in the open position.

8. Alarm Gages—The ordinary spring pressure gage with electrical connections, and arranged so that the hand or pointer makes contact with a metal pin at the desired pressure, has been used in some localities as a method of giving an alarm when sprinklers operate. When such an alarm gage is used, an excess pressure is maintained in the sprinkler piping, and the alarm is given when the pressure is reduced to slightly below normal. Alarm gages have not been developed to a point nor used sufficiently to warrant their consideration, under ordinary conditions, in place of the customary water flow alarm valve.

TESTS.

9. Failure to test periodically has been responsible for a very considerable portion of the trouble experienced with water flow alarm valves. Points that warrant particular attention include the following:

a—Circuits and wiring to be installed in accordance with the N. F. P. A. rules on Signaling Systems.

b—A reliable source of current supply to be provided.

c—Mechanism to be inspected and tested for corrosion, loading, sticking of parts, and freezing.

d—Protection of water motor rotary gongs against snow and ice, dust and dirt, and birds' nests and insects is essential. There should be a screen in the inlet pipe to prevent clogging, and this should be cleaned frequently.

e—Tests to be made by opening test pipe at the top of riser on a wet-pipe system and by means of a special by-pass where a dry pipe is used. See arrangement for rule tests shown in Fig. 119. The main drip is often used for testing wet-pipe alarms but this does not give similar conditions to the opening of one sprinkler, and the test pipe at top of riser is the proper test.

10. Caution—Before testing any alarm system, it is necessary to ascertain that the system is not connected to a central station or to the fire department. If system is so connected, special arrangements should be made satisfactory to all interests before tests are undertaken. It is also desirable, before testing local alarms, to make certain that there is no danger of unduly disturbing or exciting the employees or the public, and to make suitable provisions in advance to meet this feature.

DRY-PIPE VALVES.

11. The attachment of an electric circuit closer and a rotary gong to a dry-pipe valve is a relatively simple matter, and those dry-pipe valves which are not so equipped should be provided with this desirable additional feature.

12. The value of such an alarm attachment, however, is lost when a system is tripped and kept "wet" instead of "dry." The insurance organizations and the underwriters generally require that air be kept on a dry-pipe system at all times so that the alarm attachment will be operative, as well as for other reasons, and, therefore, it is not customary to install an alarm valve in addition to the dry valve. Where, on account of unusual conditions, it seems necessary to provide an alarm valve in addition to a dry valve, alarm valve should be placed below, that is, on the supply side, or it should be located in a by-pass in multiple with the dry valve and with necessary gate valves to permit either valve to be used independently of the other.

13. Even if a dry valve is located on the system side of an alarm valve, it should be connected to the alarms used with the alarm valve or it should have separate alarm gongs. The alarm gongs attached to the wet-pipe alarm valve cannot be relied on to operate in case the dry valve trips due to low pressure.

SPRINKLER SUPERVISORY SERVICE.

14. As covered by section on this subject in Chapter 29, Automatic Sprinkler Protection, sprinkler supervisory service is designed to give central station notification in event of water flowing through system in a sufficient quantity to operate sprinkler alarm valves. Such notification may be in addition to the customary local alarm service. Sprinkler supervisory attachments can be made to any standard water flow alarm valve. The rules pertaining to Automatic Sprinkler Alarm and Supervisory Service included in the Signaling System Rules should, of course, apply to any sprinkler supervisory service installations.

SERVICE RECORD

15. There has been considerable difference of opinion as to the actual value or reliability of commonly installed water flow alarm equipment. The extensive records of the National Fire Protection Association show conclusively that the percentage of failures of water flow alarms is relatively small and much smaller than for other agencies upon which reliance is placed for alarms, such as thermostats or watchmen. When it is considered that the existing record has been made in part by old and unapproved devices, it is safe to conclude that the modern alarm valve can be classed as a thoroughly reliable and valuable device.

MODERN WATER FLOW ALARM VALVES.

16. In the following pages are illustrated and described the more common types of water flow alarm valves, including those approved by the Underwriters' Laboratories.

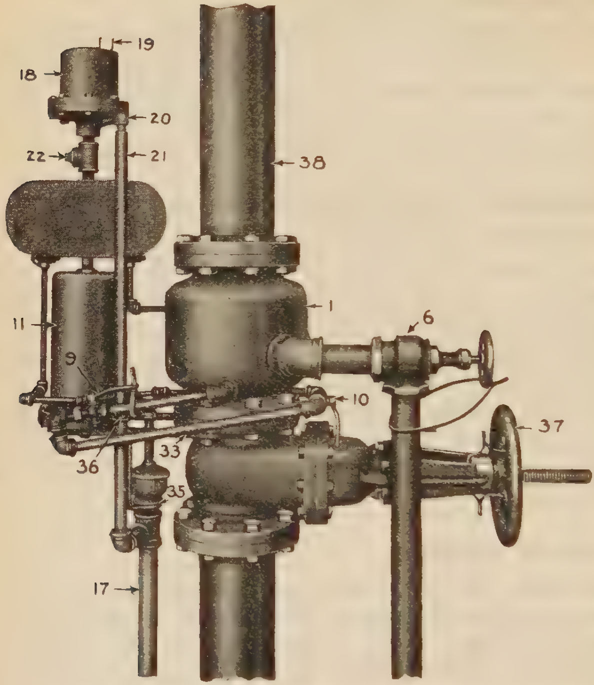


FIG. 109. TYPICAL ALARM VALVE FOR SPRINKLER SYSTEMS SHOWING CONNECTIONS AND ATTACHMENTS

(Courtesy of Grinnell Company, Inc.)

NAMES OF PARTS

1. Alarm Valve. 6. Main drain valve (closed). 9. Control valve for alarms (open). 10. Test cock (closed). 11. Retarding chamber. 17. Drain. 18. Electric circuit closer. 21. Drain from circuit closer. 22-23. Feed pipe to water motor alarm. 25. Water motor. 26. Striker. 32. Drain.

GRINNELL VARIABLE PRESSURE ALARM VALVE

(English type, no longer manufactured)

(Grinnell Co., Inc.)

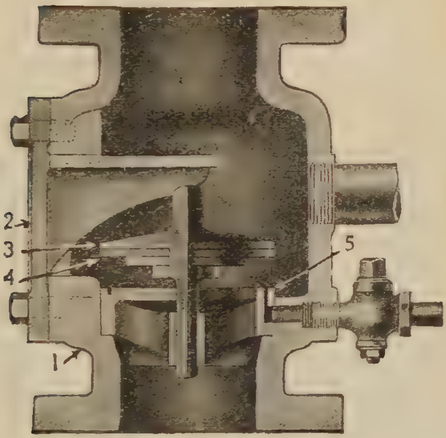
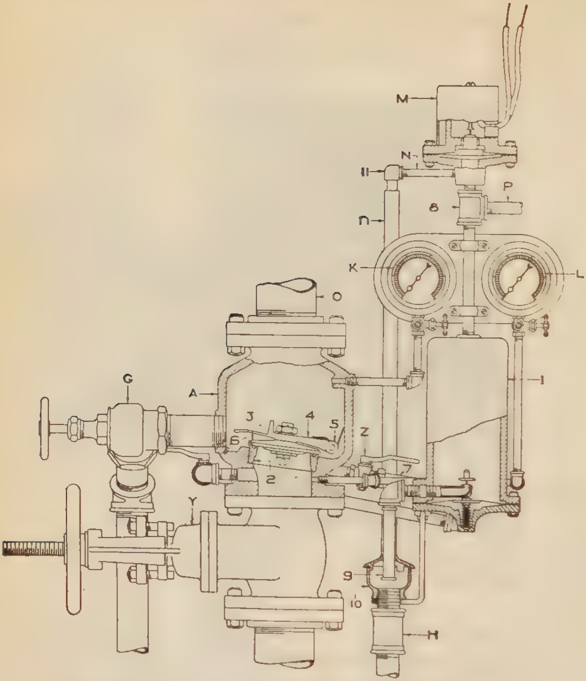


FIG. 110. NAMES OF PARTS: 3–4, Vertical check valve with composition disc. 5, Channel seat leading to alarm attachment.

17. It is to be noted that most of these valves make use of a straight way check valve in the main pipe, designed when in open position to offer minimum retardation to the flow of water. Upon the check valve leaving its seat, water flows into the retardation chamber. The design of this chamber is such that no alarm will be given unless water flows continuously for from 15 to 30 seconds. This feature is very important in that it avoids false alarms from water hammer or other causes. If the check valve remains off the seat long enough to permit the retardation chamber to fill, the motion of a valve gives a direct water supply to the electric closing device and to the water motor which drives the rotary gong.



GRINNELL STRAIGHTWAY ALARM VALVE

Model No. 1

(Grinnell Company, Inc.)

Fig. 111. Description: 1, Retarding chamber. When check raises, water flows through channel seat 6 and pipe 7, and a few seconds elapse before pressure is created in chamber 1. This pressure acts on diaphragm and closes the outlet at bottom of chamber. The water can then flow to motor gong and operate electric circuit closer. 3 is a swing check, pivoted at 5. Z is the shut-off valve for all alarms. 9 is the drain from retarding chamber.

GRINNELL STRAIGHTWAY ALARM VALVE

Model A

(Grinnell Company, Inc.)

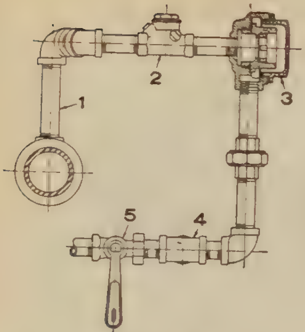


FIG. 112 A

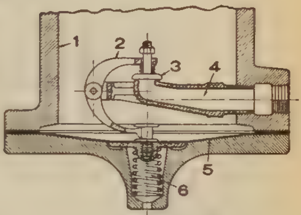


FIG. 112 B

FIG. 112 A and B. DESCRIPTION: Similar to Model 1, except for a by-pass from below the alarm check to the main drain valve above the alarm check, see Fig. 112 A. Also changes in the retarding chamber, see Fig. 112 B.

FIG. 112 A. 1, Pipe connected to main drain, close to body of alarm valve. 2, Check valve which holds water pressure in system above alarm check. 3, Fitting provided with small monel metal orifice. 4, Tee for pipe connection to alarm valve body below alarm check. 5, Test valve for alarms.

GLOBE ALARM CHECK VALVE

Model E

(Globe Sprinkler Co.)

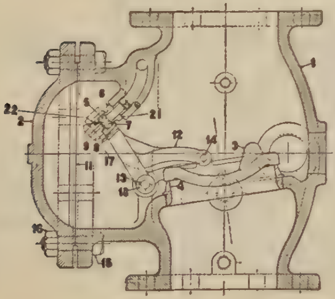


FIG. 113 A

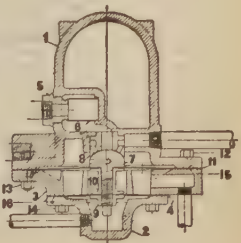


FIG. 113 B

FIG. 113 A. ALARM CHECK. 3 is swing check connected by levers to auxiliary valve 6. When 3 raises, it opens valve 6 and water flows through 5 to upper section of retarding chamber.

FIG. 113 B. RETARDING CHAMBER. When upper section is filled, pressure is exerted on diaphragm 11 and this operates valve 7 and water is supplied directly from alarm valve through opening 8 to the alarm mechanism.

INTERNATIONAL ALARM CHECK VALVE

("Automatic" Sprinkler Corporation of America)

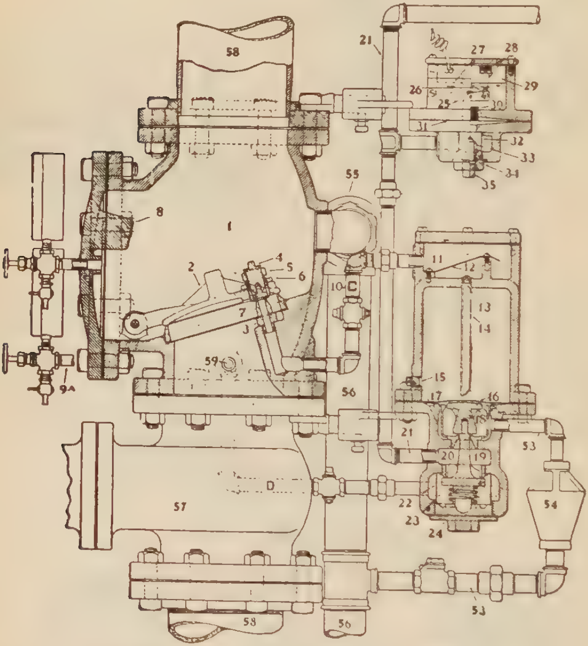


FIG. 114. NAMES OF PARTS. DESCRIPTION: 2 is swing check with auxiliary valve 7, closing outlet leading to retarding chamber 11. Water flows through 13 and exerts pressure on diaphragm 16. This opens valve 23 against the water pressure from system through pipe 59 and allows water to flow through 21 to the electric and water motor gongs. Under normal conditions water in 21 drains through 53, and there is a hole at 17 which allows drainage from retarding chamber.

VENTURI ALARM VALVE

("Automatic" Sprinkler Corporation of America)

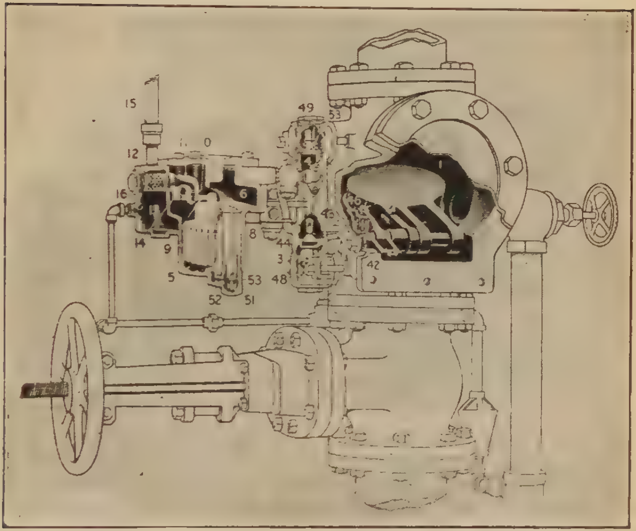


FIG. 115. DESCRIPTION: 2 is a weighted check valve with attached arm carrying clapper 46, which latter closes opening to pipe 44 leading to 4 which is the upper part of a Venturi Tube. This Venturi Tube is a by-pass around main check 2. The upper tube 4 has a check 53 which prevents water in system passing back through tube. 5, 6 is a double chambered valve with connection 52. 5 is connected with the Venturi Tube at its larger section, while 6 is connected to a separate chamber surrounding Y. Mercury is placed in chamber 5, in which is iron weight float 7, attached to which is lever 9, and valve 10. With small flows of water check 2 remains closed and water flows through Venturi Tube and pressure at Y is decreased, which in turn decreases the pressure in 6. Some mercury flows from 5 to 6, lowering weight 7, and opening valve 10 which allows water to flow to 15 and the alarm devices. The time element is provided by having the mercury pass through a small hole in check 51. The small clapper 46 does not function if main check remains on its seat and is provided to give alarm in case check 2 is off its seat for any reason.

ROCKWOOD VARIABLE PRESSURE ALARM VALVE

Type B

(Rockwood Sprinkler Co.)

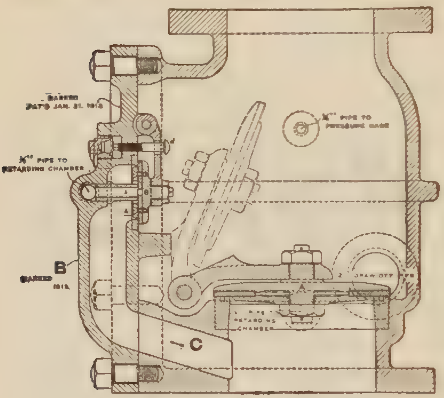


FIG. 116. DESCRIPTION: Swing check A closes channel seat ring connecting through independent pipe to retarding chamber. Auxiliary and independent check B closes opening to another pipe leading to retarding chamber. B opens on small flow and A opens if more than 2 or 3 sprinklers operate.

SECTION G—ALARM SYSTEM

(Automatic Sprinkler Rules—1922 Edition)

41. Gongs and Connections—Every automatic sprinkler system should contain an alarm apparatus so constructed that a flow of water through same will operate an electric gong, a mechanical gong, or both, as the character of the property and circumstances may require. On wet-pipe systems, or partially so, this apparatus should consist of an alarm valve and attachments; on dry-pipe systems, attachments to dry-pipe valve (see Section H), except that where there is an approved supervisory system to a central station, one of the local alarms may be omitted at the discretion of the Inspection Department having jurisdiction. In other places, especially in small towns, alarm valve or dry-pipe valve may be connected with public fire department house, or some other suitable place.

The use of both electric and mechanical gongs is strongly recommended. The gong of the latter type can be located on the outside of building or any other desirable place on the premises. When located on the outside all gongs shall be protected from the weather. Electric bells shall be of standard type.

UNITED STATES ALARM VALVE

Grimes Model

(United States Automatic Sprinkler Co.)

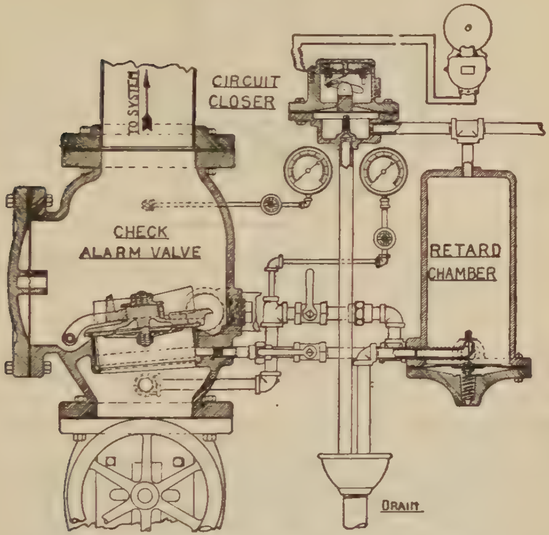


FIG. 117. DESCRIPTION: The seat ring of main check is grooved and connected by slots to a lower chamber around the seat ring. This latter chamber is piped to the retard chamber. The retard chamber has an opening at the bottom which is closed by a diaphragm actuated valve, and an opening at the top leading to the alarm devices.

Rotary gongs should be located as near alarm valve or dry-pipe valve as possible. Attention is called to the necessity of avoiding long runs or many angles in pipe to rotary gong. The total length of pipe horizontally should not exceed 75 feet, and vertically 20 feet.

All pipe between alarm valve, dry-pipe valve, and rotary gong should be galvanized or brass of a size not less than ¾-inch, and larger for long runs of piping or where pressures are low; and arranged to drain properly through not larger than a ⅛-inch orifice, brass bushed.

Water motor and gong should be properly aligned and so installed as not to be liable to get out of adjustment.

The drain from the water motor should be properly connected. See Rules 37, 39, and 46.

Authors' Note—Some fire protection engineers feel that the word "should" in the first line ought to be changed to "to," thus requiring an alarm valve for every sprinkler system. It is certain that the value of a good sprinkler alarm cannot be too strongly emphasized, particularly from the standpoint of the property owner, and compared with the expense the additional protection afforded is very great.

F. P. C. ALARM VALVE

(Fire Protection Co.)

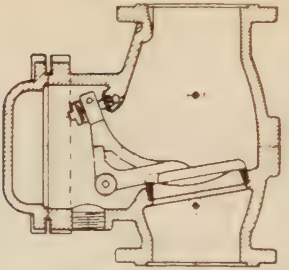


Fig. 118. Description: Swing check valve with small auxiliary valve operated by lever attached to main check. The auxiliary valve closes the port leading to a retarding chamber.

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42. Alarm Apparatus—Shall be so located that the passing of water through any of the automatic sources of supply to any of the sprinklers will cause its action.

43. Approval—Alarm valve or other alarm apparatus should be approved by the Inspection Department having jurisdiction.

Authors' Note—Some of the older types of sprinkler alarms are a menace to the entire system in that they may fail to open and therefore prevent the water from reaching the sprinklers. Check valves with packed stems and outside levers are especially susceptible to sticking and numerous cases have been found where such check valves would not open under low tank pressures. Furthermore, these checks are unreliable and frequently out of service so far as giving alarm is concerned. All checks of this pattern should properly be removed from the sytem.

The old style angle check with a protruding pin is also defective in that the pin sometimes becomes bent, corroded, or stuck and prevents the valve from opening.

44. Wiring and Energy for Electric Alarms—Should be installed in accordance with the rules of the National Board of Fire Underwriters. (See Signaling Systems.)

Authors' Note—The rules on Signaling Systems include sprinkler supervisory service as well as water flow alarms, and rules for wiring and for central station service.

45. Alarm Valve Installation—The alarm valve, retarding chamber and circuit closer shall be so located that all parts will be readily accessible for inspection, repair, or removal, and all shall be substantially supported. Suitable valves shall be provided in the connections to the retarding chamber to permit repair or removal without shutting off sprinkler system. These valves should be arranged to be readily secured open.

46. Drains—A vent should be provided for circuit closer. Where used, should be properly piped to a drain.

Drains at alarm valve and at the variable pressure chamber, circuit closer, and rotary gong connected with valve, shall be so arranged that there will be no danger of freezing, and also so protected, by checks or otherwise, that there will be no overflowing at the alarm apparatus or of domestic connections that may be on the same drain, with the sprinkler drain wide open. Where checks are used, they should have the equivalent of at least a four foot head and not be installed in a vertical position "looking down."

Drains from retarding chamber and circuit closer should discharge either to open cone connected as above, or the drain from alarm valve run separate from the other drains to the sewer or ground drain, a union or plug being inserted in each drain to permit of inspection.

Where drains are connected with a sewer, proper trap shall be provided.

Cold air has been known to enter drain-pipes from retarding chambers of alarm valves sufficiently to cause trouble by freezing in the alarm check valve. Where exposed to frost and it is necessary to drain alarm valves outside the wall, an open discharge cone should be provided inside to break the pipe line so that cold will not be conducted directly into retarding chamber. (See Section F, Rule 37.)

CHAPTER 32

DRY-PIPE VALVES FOR AUTOMATIC SPRINKLER SYSTEMS

1. In many buildings it is impossible to heat the premises so as to prevent water in sprinkler pipes from freezing, and in such cases it becomes necessary to use what is known as the dry-pipe system. In such a system the pipes are full of air instead of water, the air being under pressure. In the feed pipe to each dry-pipe system is a dry-pipe valve, which is an automatic device designed to hold back the water until the air pressure has been reduced through the opening of one or more sprinkler heads.

2. The use and development of dry-pipe valves has evolved two general types, into which all valves now in use may be grouped. These are generally spoken of as the differential and the mechanical. In both cases the design is such that a relatively small air pressure will hold back a much greater water pressure.

DIFFERENTIAL DRY-PIPE VALVES.

3. In the differential type of dry-pipe valve there are used two clappers of unequal size, assembled more or less as a unit, the larger clapper subjected to air pressure and holding to its seat a smaller clapper subjected to water pressure. In this type of valve mechanical imperfections are compensated for either by a flexible clapper or by a flexible seat. The trip point of this type of valve is determined by the ratio of the area of one clapper to that of the other, and sufficient air pressure must be carried to overcome the water pressure. The ordinary ratio of water to air pressure is about 1 to 6.

4. With ordinary pressures ranging from 50 to 100 lbs., the tripping air pressure will be about 15 lbs. or even less, but in order to have a margin of safety it is customary to cary air pressures of 30 to 40 lbs. Since the air pressure in the system must be reduced to the tripping point before water enters the piping which is normally dry, it is undesirable to carry a greater margin of air pressure than necessary, as greater time must elapse before the water reaches the sprinkler heads.

5. Figs. 121 to 125, and 131 to 133, on succeeding pages, illustrate approved forms of differential dry-pipe valves.

MECHANICAL DRY-PIPE VALVES.

6. In the mechanical type of valve, the air and water seats may or may not be of the same area; in each example of this type of valve the air clapper, under the influence of air pressure, holds the water clapper shut against a pressure of water which may be greater than the pressure of air. This is accomplished through a system of reducing levers. Valves of this type also are designed to compensate for mechanical imperfections.

7. The ideal in each type of mechanical valve that the designer has attempted to reach is having in his train of mechanism a weighted lever tending to open the air valve when the pressure reduces to a predetermined point, and so proportioning the balance of his lever train that the water pressure has little or no effect upon the opening of the valve. Theoretically, a mechanical dry-pipe valve has a definite operating point that is affected slightly, if at all, by the water pressure. This ideal, however, is hard to attain in practice due to the deflection of levers under extreme loads and to the set at the bearings through a long period of inaction. In consequence, the trip point is affected more or less by the stress the operator puts upon the compensation means, which is usually a stress screw.

8. Figs. 127 to 130 illustrate approved type of mechanical dry-pipe valves. No. 126 is designated by the manufacturer as semi-mechanical.

ADVISABLE USE OF DRY-PIPE VALVES.

9. Wherever it is feasible to heat a building, this is advisable in preference to using a dry-pipe system, for such a system introduces features tending toward more frequent interruptions to automatic service. The dry-pipe valve itself is a mechanical device which, however, well constructed, needs attention, and, furthermore, the proper air pressure must be maintained or water will enter the system. It has frequently been found difficult

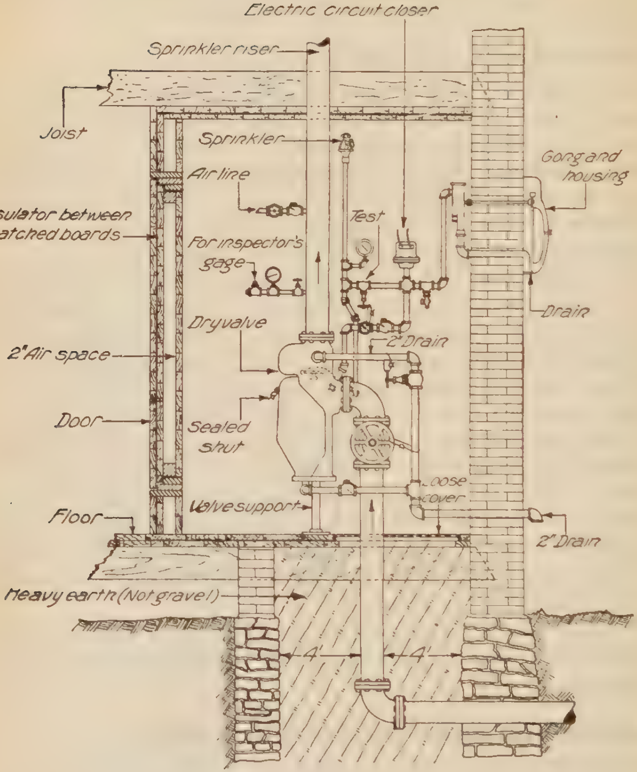


FIG. 119. DRY PIPE VALVE ENCLOSURE

thoroughly to drain a system, and consequently freezing with possible crippling of the system occasionally results. Dry-pipe valves and the piping below them must be protected against freezing. Frequent inspections of dry-pipe valves and systems are necessary, especially to guard against accumulation of water above the dry-pipe valves with resultant "water columning." Such accumulation may be due to an improperly drained system or to leakage past the dry-pipe valve.

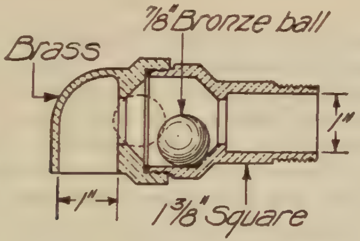


FIG. 120. AUTOMATIC BALL DRIP

(Courtesy Factory Mutual Fire Insurance Companies)

Drip is normally open. A flow of about seven gallons per minute seats the ball and closes the drip.

10. Many of the older types of dry-pipe valves are thoroughly unreliable, and only modern, approved types should be used. A dry-pipe valve is a delicate piece of mechanism, and it must be thoroughly studied before judgment can safely be passed upon its condition. On one unapproved form of mechanical dry valve, for example, the use of rubber gaskets in an air cup has been found frequently to put the valves entirely out of commision.

11. While considerable emphasis has been placed in the past upon the danger of interruption to service where dry-pipe systems are in use, experience has shown that these difficulties are relatively unimportant with modern apparatus and systems, and it must not be forgotten that wet systems are also subject to interruption of service, especially owing to freezing. Unusually cold weather, lack of coal, carlessness of employees in not maintaining proper temperatures at night, windows left open, and other oversights cause freeze-ups of wet systems.

SIZE AND EFFICIENCY OF DRY SYSTEMS

12. It is recognized that in theory, at least, the most serious objection to the use of a dry system is the loss of time between the opening of a sprinkler and the issuance of water. This gives time for the fire to spread considerably and more sprinklers are opened.

According to the fire record about twice as many sprinklers open on the average with dry systems as with wet systems, which shows that the control of fire is not as prompt or certain with a dry system.

13. The following figures, taken from the 1922 tables of the N. F. P. A., show that one sprinkler on a wet system takes care of a larger percentage of fires than two sprinklers on a dry system. Two sprinklers or less with a wet system is as effective as five or less with a dry system. Nearly 5 per cent. of all fires with dry systems opened more than 100 sprinklers while less than 1½ per cent. of the fires with wet systems opened over 100 sprinklers.

No. of Sprinklers Operating.	Wet.	%.	Dry.	%.
1	7708	35.5	871	19.6
2 or less	11539	53.1	1476	33.0
3 or less	13741	63.3	1850	41.5
4 or less	15309	70.6	2178	48.8
5 or less	16300	75.1	2386	53.5
10 or less	18815	86.7	3035	68.0
15 or less	19773	91.0	3414	76.5
25 or less	20555	94.5	3764	84.5
Over 100	306	1.4	218	4.9

14. A comparison of the efficiency of wet and dry systems is shown in the following table:

	No. of Fires.		No. of Fires.		No. of Fires.		
	Wet.	%.	Dry.	%.	No. Data.	Total.	%.
Practically or entirely extinguished	14,718	66.1	2,925	63.7	13	17,656	65.7
Held fire in check	6,721	30.2	1,362	29.8	8	8,091	30.0
Unsatisfactory	835	3.7	297	6.5	9	1,141	4.3
Total	22,274		4,584		30	26,888	

15. This shows about twice as many unsatisfactory fires with dry systems as with wet. Of the 297 unsatisfactory fires with dry systems less than ten per cent. are classified as due to trouble with the dry system itself and it therefore appears that many of these unsatisfactory fires are directly due to the delay in getting water on the fire.

16. In the early years of sprinkler protection there were no definite limitations to the size of dry systems, and 1,000 to 1,200 sprinklers on a dry valve was somewhat common. It was found however that with a system of this size, several minutes (say 3 to 5) might easily elapse between the time the sprinkler opened and the water reached the fire. This lapse of time was caused by the large volume of air in the sprinkler pipes. Because of this large volume, considerable time necessarily elapsed before the normal air pressure in the system was reduced to the pressure at which the air valve trips.

17. Under more modern rules, the number of sprinklers allowable on one dry valve was placed at from 300 to 400 at most, and in many cases 250 was considered sufficient. With normal air and water pressure the loss of time with these more modern systems should not exceed one to two minutes.

18. It is, of course, evident that the greater the air pressure the longer the time element, assuming the water pressure and air pressure at which the dry valve operates to be constant. It is, therefore, important to carry only sufficient air pressure to have the valve safe against premature tripping. If the system is fairly tight the excess air pressure over the operating pressure should not be over 15 to 20 pounds, and if there is abnormal leakage, the system should be made tight rather than to carry an extra heavy air pressure to care for this leakage. Even 10 or 15 pounds more air pressure than is necessary may cause serious delay in water reaching the fire.

19. The instruction sheets provided for the various types of dry valves give operating air pressure and the required air pressure for safe practice. Care should be taken not to exceed this air pressure.

20. It has long been recognized that the time element could not be altogether or properly regulated by a rule limiting the number of sprinklers on a system, for this does not necessarily limit the capacity of a system on which the time element depends. There may be long runs of large pipe which greatly affect the capacity of the system with the same number of sprinklers. Furthermore, even without such somewhat unusual conditions, the number of gallons of pipe capacity per sprinkler head varies from three quarters to over one and a half gallons per sprinkler simply due to various methods of piping or construction. The average number of gallons capacity per sprinkler is probably about 1¼ gallons, not taking into account any long runs or main feeders. (See Rule 48, page 583.)

21. In 1921 the Rules were amended and changed to provide for a maximum capacity of 500 gallons for one dry valve. This necessitates the use of a table for pipe capacities. See Table 34, page 728. See also Table 35 for examples of capacity of amount of water in sprinkler piping. At this time the Rules were further amended to permit not more than 1,000 gallons on one dry valve provided the dry valve was equipped with a quick opening device or "accelerator."

DRY PIPE VALVE ACCELERATORS.

22. A quick opening device or accelerator was first developed by the Grinnell Co. Inc., and put on the market in 1920. Since then other devices of this general character have been put on the market. This device is so constructed that the dry valve will trip as soon as there is a quick reduction in the air pressure in the system, amounting to 1 pound or less. In other words, the dry valve trips in a few seconds after the sprinkler operates. There is but little difference in the time elapsing between the tripping of dry valve and water reaching the sprinkler, with or without an accelerator. With an accelerator 20 to 30 seconds is a fair estimate of the loss of time after a sprinkler operates before water comes, while without an accelerator this loss of time might easily be 4 or 5 times as great even with a standard system. The loss of time with an accelerator is so small that the time element disadvantage of a dry system practically disappears and so far as this important feature is concerned the dry system becomes the equivalent of the wet system. See page 599.

23. The Globe Automatic Sprinkler Co. also have an approved accelerator (see page 601).

24. The "Automatic" Sprinkler Corporation of America have developed a device called an Exhauster which answers a similar purpose (see page 602).

25. Old or "overloaded" dry systems which are sub-standard because of the size of system can be made much more satisfactory by the use of an accelerator. All dry-pipe valves should be equipped with a device of this nature so as to increase their efficiency.

BY-PASS CONNECTIONS.

26. The Associated Factory Mutual Companies generally require that all dry-pipe valves be installed in a by-pass. They consider this desirable:

27. *First.* In order that the dry-pipe valve can at any time be removed from the system, as is occasionally necessary, and the sprinkler equipment kept intact.

28. *Second.* In order that in the spring, when the equipment is changed to a wet system, the dry-pipe valve may be readily cut out and taken care of, so that upon the approach of freezing weather it may be ready for immediate service.

29. *Third.* If for any reason the dry-pipe valve should fail to open promptly, the water may be easily admitted through the main connection.

30. They use a "short" and a "long" by-pass. The short by-pass provides for a single feed pipe with the controlling valves for both the by-pass and main feed located in a dry valve house or enclosure. The long by-pass provides for two main feeders, each having outside post indicator control, one for the dry valve and one for the wet pipe feeder. The short by-pass is less expensive and generally desired but the long by-pass is used with large areas or where the dry valve is located near center of building.

CARE AND INSPECTION

31. Drainage—All portions of a dry system must drain properly. This necessitates ample pitch for all piping and special drains at all low points. Before cold weather all drains should be opened, water drawn off, and valves, cocks, or plugs tightly closed to prevent air leakage. Frequent tests of these drains should not be necessary unless water is found to accumulate at certain points or unless the dry valve trips and allows water to enter system. A test of drains once every two months should be sufficient, and it may be advisable to omit all such tests in freezing weather.

32. Valve Room or Closet—Inspect at least once a week to see that temperature is always well above freezing. At the same time examine general conditions, tightness of doors, main valve open and fastened, and alarms operative.

33. Dry Pipe Valve—Essential matters of an inspection and upkeep character are:

a—See that main gate valve is open and fastened.

b—Note pressure shown by air gauge. Air pressure should not be more than about 20 lbs. above the normal air pressure at which valve trips. Air gauges are often incorrect and they should be tested from time to time; otherwise air may drop to the danger point. If air pressure is more than required, more time will elapse before water reaches the sprinklers.

c—Note water pressure below dry valve and test for water flow by opening the 2-inch test pipe wide and note drop in pressure.

d—See that air compressor is in good working condition. The valve in air line should be kept closed.

e—See that all valves or cocks controlling alarms are open and fastened.

f—Test alarms by means of test valves or electric switch. Do not test water motor gongs in freezing weather except a hand test of shaft and striker to make sure it will move freely.

g—Test for water in main riser above dry valve by opening air test valve and draw off all water at this point, being sure that valve is closed tight after test and does not leak air. This test does not need to be made oftener than once in two months unless considerable water is found above the valve, and this test is inadvisable in freezing weather.

h—If there is a test cock for priming water, this test should be made and this will show that there is sufficient priming water above valve. Many dry valves do not have a priming chamber and test cock.

i—The automatic ball drip at dry valve should be examined frequently to make sure that it is unobstructed and in operative condition. See Fig. 120. If this drip becomes clogged water may leak into the body of valve and cause trouble, and in some cases water could leak through into main piping.

j—Some types of valve have a separate air disc with test cock. This test cock or valve should be tested frequently and any water above the air disc drawn off to prevent water column. (See Manufacturers No. 3; Niagara, Model G.)

k—Differential type of dry valves are provided with a latch or catch to prevent reseating and possible water column. In some types this latch or catch can be tested to see that it operates properly and freely. This test is particularly necessary on Grinnell No. 12 as the latch is operated by a spring. (See also Grinnell C and D; K. M. E., Model A.)

SETTING DRY-PIPE VALVES

34. The details of setting vary with various types of valves and the directions provided with each valve should be carefully followed. In general:

a—Be sure that all water has been drained from system and body of valve, otherwise water may come out when hand plate is removed.

b—Carefully clean all air and water seats and rubber gaskets, otherwise these seats may be ruined, requiring expensive repairs.

c—Put clappers, disc, and valve parts in proper position.

d—See that air clappers are primed with water.

e—Pump up the necessary air pressure and open main gate valve.

35. Caution—Never apply grease, tallow, or any oily substance to valve seats or discs. If properly cleaned, they should hold tight unless they have been injured in some way in which case it is usually necessary to have the valve repaired by the manufacturer.

BACK FLOW AND WATER HAMMER

36. Field tests have shown that if water flows in a reverse direction through certain types of valves, the air clapper may be slammed upon its seat so suddenly by this back flow that the resulting water hammer is sufficient to break the body casting. This is most likely to happen with two or more valves on a header, tripped in succession, the sudden discharge of water into the empty system causing a reverse flow in the dry valve previously operated.

37. Certain changes in design will overcome this trouble in new valves, and changes have also been recommended for certain valves now in service such as the Manufacturers and Niagara.

DRY-PIPE VALVE ENCLOSURES

38. The National Fire Protection Association have issued a set of illustrations showing different types of dry-pipe valve enclosures. One is illustrated in Fig. 119, where also is shown a dry-pipe valve with all customary connections and test provisions.

FIELD TESTS

39. In a previous edition of the Hand Book, the results of field tests published in the October, 1914, N. F. P. A. Quarterly were summarized. The following gives some of the reasons for unsatisfactory action:

a—Air all gone, barely released.
b—Set three years, failed at first, later tripped.
c—Set three years, almost failed despite high pressure.
d—Rings ruptured, some water damage.
e—Failed from water column.
f—Hand hole blew out.
g—Failed by sticking.
h—New valve burst, no cause determined.
i—Stuck because primed with thick grease.
j—Failed because capable of being improperly set.
k—Valve had been abused.
l—Upper check cracked.
m—Double failure, valves stuck.
n—Logy and tripped far below normal.

40. The January, 1921, Quarterly gives results of field tests in Canada, and the following is taken from this report:

While dry-pipe valves have operated properly after being set "dry" for a considerable number of years, such a long delay in testing is felt to be poor practice, and is not the general rule with other portions of a sprinkler equipment, such as fire pump, alarm valve, water supplies, and so forth. The reliability of a whole system may be dependent upon the proper operation of the dry-pipe valve, and it should, therefore, be tripped regularly.

The failure of a dry-pipe valve does not necessarily imply an inherent defect, but may be due to improper setting, substitution of or addition to parts, poor maintenance, local surroundings, condition of water supply, or other causes. Poor shop practice or structural defect has, however, contributed to some failures, making necessary the replacement of the valves to avoid courting disaster in case of fire.

41. Of two failures at time of fire, one was due to replacement of a small part of the valve by a home-made piece which threw the adjustment out of line; the other was due to binding of parts caused by faulty adjustment of set screw.

42. The following are results from field tests:

a—Seven failures due to corrosion, rust, scale, or sediment.
b—One due to white lead on air clapper.
c—One due to blowing out of hand plug on account of corrosion.
d—Ten failures due to sticking at the auxiliary air cup, caused in some cases by inserting a gasket or washer.
e—A releasing part became wedged between the body of the valve and the rod of the water clapper.
f—Stones prevented water clapper from going into place.
g—Ice in anti-column pipe caused failure.
h—Seven valves found water columned due to letting water into system during warm weather, setting valve and draining intermediate space.
i—Four valves reseated owing to trouble with latch.
j—Failure of four valves and replacement of eight valves due to poor shop practice or structural defects.
k—Four fractures of valve bodies and five of fittings above the valve, when valve operated; these occurred with a dry

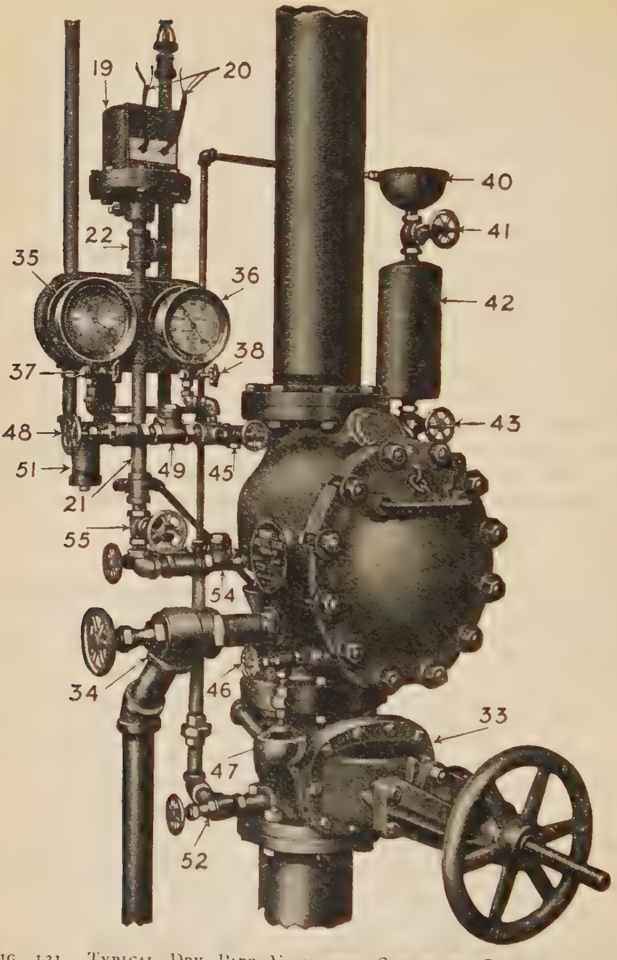


FIG. 121. TYPICAL DRY PIPE VALVE FOR SPRINKLER SYSTEMS, showing connections and attachments. (Courtesy of Grinnell Company, Inc.) 19, Electric alarm circuit closer. 22, Connection for feed pipe to water motor alarm gong. 33, Main gate valve (should be fastened open). 34, Draw-off valve (kept closed). 35, Water pressure gage. 36, Air pressure gage.

(See bottom of next page.)

valve which had been tripped, followed by the tripping of another valve. A serious loss occurred in New England under similar conditions.

SECTION H—DRY-PIPE SYSTEM AND FITTINGS

47. Where Necessary—A dry-pipe system should be required **only** where a wet-pipe system is impracticable, as in rooms or buildings which cannot be properly heated. The use of an approved dry-pipe system is, however, far preferable to entirely shutting off the water supply during cold weather.

Where it is necessary to have but twenty-five (25) per cent. or less of the total number of sprinklers on an air system, only such sprinklers should be thus piped; the remainder shall be placed on wet system.

This rule requires small dry-pipe systems for show windows, blind attics or other minor portions exposed to freezing.

Sprinklers in minor portions exposed to frost, if the total number does not exceed ten, may be connected to wet system and provided with shut-off and drain, except where occupancy conditions may prohibit such an arrangement, in order that the equipment may be drained during the winter months. (See also Section K, Rule 81.)

Authors' Note—The undesirability of shutting water off of any of the sprinklers cannot be too strongly emphasized. All portions of the building should be heated or the sprinklers placed on a dry-pipe system. This includes entry ways, show windows, cock lofts, and basements. Small dry-pipe valves (2½ and 3 inches) can be purchased and these can be used where there are only a few sprinklers so located as to be in danger of freezing.

48. Size of Dry System—The capacity of a system depending upon one dry-pipe valve should not exceed 500 gallons.

Where the dry-pipe valve is equipped with an approved quick-opening device and Inspection Department having jurisdiction permits, the capacity of a system may be 1,000 gallons.

Table of Capacities of Wrought Pipe—There is no standard for all manufacturers. The outside diameter of pipe is made exactly to standard in order to fit the dies. The skelp from which the pipe is made is of a thickness to make the pipe weigh the standard per foot; but a variation of 5% above or below is permitted. The inside diameter and therefore the capacity will vary slightly and no table is strictly accurate. The fittings will also make a slight difference, but for the application of the above rule, the following table is substantially correct:

Nominal Internal Diameter in Inches	U. S. Gallons in One Lineal Foot of Pipe
¾	.028
1	.045
1¼	.078
1½	.106
2	.174
2½	.248
3	.383
3½	.513
4	.660
5	1.040
6	1.501

40, 41, 42, 43, priming chamber, cup and control valves. 45, Test valve used to draw off any water above this point. 46, Drain for body of dry-pipe valve. 48, Valve in air supply pipe from compressor. 49, Check valve on air supply pipe. 51, Strainer on air supply pipe. 52, Gate valve controls water feed pipe to water gage, alarm test pipe, and priming cup. 54, Check with small hole in clapper for draining alarm piping. 55, Gate valve controls feed pipe to alarms (should be fastened open).

The gallons per sprinkler will naturally vary with the arrangement of the system. Under standard requirements, the smallest quantity per sprinkler would be .741 gallon under 8 ft. stagger in 11 feet 6 inches to 12 feet bays joisted construction, and the greatest 1.714 gallons under practically 10 x 10 feet spacing panel construction; but in equal areas, the total capacity of each system per floor would be nearly the same due to the greater number of sprinklers under the joisted construction. Approximate capacities may be obtained under general types of construction by allowing per sprinkler 1.1 gallons under center feed; 1.25 gallons under side and end center feed, and 1.6 gallons under panel construction. These include allowances not in excess of 14 feet for riser pipe and of 10 feet from riser to system on each floor. They do not include any long runs from dry-pipe valve to system.

Authors' Note—The above rule 48 is a radical change from former rules for size of dry systems. The former rules permitted a certain number of sprinklers on a dry system, usually 300 to 400 as a maximum. It was, however, recognized that the time element depends on capacity or amount of air in a system rather than the number of sprinklers.

A rough estimate of one and one quarter gallons per sprinkler, not including long runs or feed mains, is about right for average conditions.

The ruling for systems with quick-opening devices is new, as this device has only recently been developed. (See page 599.)

49. Sub-Division of System—All systems should be divided horizontally where pressure tanks are installed.

In buildings of great area, such as piers, storage sheds, foundries, car shops, etc., substantial curtains of flame-proof material extending down 24 inches or more below the ceiling may be required to separate sprinkler systems so that there will not be more than 200 sprinklers in the pocket areas so formed.

A dry-pipe system may be still further subdivided by the insertion of check valves in the different branches of the system, thus quickening the operation of the dry-pipe valve. Holes ⅛ inch in diameter should be drilled in the clappers of the checks to equalize the air pressure under normal conditions, and a drain, properly connected, should be provided in front of each check valve. Checks and drains shall be located in a warm place.

50. Location and Protection of Dry-Pipe Valve—The dry-pipe valve should be located in an accessible place and as near as practicable to the sprinkler system it supplies.

Dry-pipe valve in any location should be properly protected from mechanical injury.

Where exposed to cold, the dry-pipe valve should be located in an approved underground pit, or in a valve room or closet. Room should be of sufficient size to give at least 2½ feet of free space on all sides of and above or below dry-pipe valve or valves, and this room, if feasible, should not be built until the valve is in position. Valve room should be well lighted, preferably by electric light and properly heated by steam, electric heater (installation to comply with the National Electrical Code), gas or lard oil lantern. If fire heat is used, some ventilation will be necessary to supply the air for combustion.

Inspection Department having jurisdiction shall be consulted as to construction and arrangement of dry-pipe valve enclosure. Illustrations of a number of types of enclosures, which have been successfully used under varying conditions, are separately published as a supplement to these Regulations, and may be obtained on application.

The supply for the sprinkler protection in the dry-pipe valve enclosure shall preferably be from the dry side of system, but if on wet side shall be controlled by a valve.

51. Pressure to be Carried—High air pressure in dry-pipe system is undesirable, and 15 to 20 pounds in excess of the normal tripping pressure of valve has been found to be the maximum which it is necessary to carry in most cases. Under these conditions, to avoid pumping oftener than once a week, the system should not lose more than about 10 pounds air pressure per week and an equipment which leaks more than this cannot be considered acceptable. (See also Section K, Rule 81.)

Air pressure should be maintained on dry-pipe systems throughout the year, except when special permission is given by the inspection department having jurisdiction to fill system with water for a short period to detect leakage.

Authors' Note—The above rules states that air pressure should be maintained on dry-pipe system throughout the year. The reason for this is that there is less chance of interruption to service where the system is once put in good condition and then so maintained. Where water is let in the system there is danger of improper drainage, faulty setting of dry valve or keeping water in the system too long after cold weather begins. A leak or trouble with dry valve may develop when changing to dry system, and if cold weather has begun it may be necessary to put system out of service entirely pending repairs. On the other hand, letting water into a dry system during warm weather allows the use of a wet system for that period, and, in warm climates where the danger of freezing only covers a few weeks and even then is more or less remote, it may be preferable to change over the system each year.

52. Air Compressor—Air compressor should be of standard type and have a capacity of not less than 11 cu. ft. of free air per minute except where the number of dry systems is three or less in which case compressor of 6 cu. ft. capacity may be used.

A standard relief valve should be provided at every air compressor and set to relieve at a pressure five pounds in excess of maximum air pressure which should be carried in system.

A direct connected steam or electrically driven air pump is preferred to a belt driven pump. The air supply should be taken from outside or from a room having dry air, in order to avoid carrying moisture in the system. The intake should be protected by a screen.

In extensive systems subject to extreme cold, the air supply should be taken from the room where the lowest temperature and driest air prevail, and drawn through a reservoir or tank of about thirty gallons capacity containing from ten to fifteen pounds of granulated calcium chloride.

53. Independent Air Filling Connection—The connection from the air compressor should enter the system in the main riser above the dry-pipe valve, and on this supply a check valve between two shut-off valves with renewable discs. Automatic supply of air to a system is not desirable except in special cases, but where two or more systems are supplied by an automatic compressor, a brass disc having ⅛-inch orifice should be installed in supply line to each system, in addition to shut-off and check valve, same to be located on compressor side of check valve.

54. Anti-Columning Pipes—When anti-columning pipes are used they shall be either lead lined or of brass.

55. Supply and Test Pipe—All water supplies to sprinklers shall enter the system below the dry-pipe valve, shall be properly protected from freezing, and provided with a 2-inch test pipe connected between controlling gate and dry-pipe valve. Test pipe should be provided with a standard valve and be properly connected to a drain, so as to permit of the valve being opened wide for a water flowing test. Pressure gauges should also be provided as called for in Section F, Rule 40.

A ¾-inch inspector's test pipe shall be installed on the end of most distant branch line and equipped with a ¾-inch shut-off valve and brass plug.

56. Drainage—Sprinklers shall be located in an upright position. All sprinkler pipes and fittings shall be so installed that they can be thoroughly drained and, where practicable, all pipes should be arranged to drain at the main drip, ordinarily located at the dry-pipe valve. The tops of branch lines should pitch at least ½ inch in 10 feet, and more where settling may occur. A pitch of ¾ inch to 1 inch is usually not impracticable with short branch lines, and should be provided where there is a chance of settling.

Where settling may occur and deprive a dry-pipe system of its drainage, the ends of lines should not be raised to violate Section B, rule 12. The drainage should be restored by shortening the vertical piping.

Where more than three sprinklers do not drain back, a drum-drip valve should be installed, if possible in a warm location. Where such number of heads is three or less, a drip valve with soft metal seat, plugged with a composition plug, shall be installed. Where more than twenty sprinklers do not drain back a 1¼-inch drain valve shall be provided with drain pipe discharging to a safe location.

57. Connection from Top of Pipe—Where the supply for these low sprinklers is taken from a large pipe, such as a trunk main, the connection should be made from or near the top of the large pipe, so as to prevent condensation in same entering the small pipe. This can be accomplished by looping back the connection.

Where feasible, the drains for these low portions should be carried back into warm rooms, and the drip valves located there.

One half-inch Test Pipe—In cold climates, where there may be a considerable number of sprinklers or low point in large pipe drained by a separate drip, requiring a drain valve 1¼-inch or more in size, it is advisable to provide either a condensation drip or a ½-inch drip valve back of and below the larger drain valve. This latter arrangement will permit the blowing out of these low pipes through the ½-inch valve, when there might be danger of tripping the dry valve by opening the larger drain.

58. Dry Pipe Underground—When it is necessary to place pipe which will be under air pressure underground, it is desirable that it be buried below frost, so as to prevent any trouble from the heaving action of frozen ground. This pipe should be wrought and have at least two coats of good rust-proof paint, such as asphaltum, tar, etc., one coat to be applied before the pipe is laid, and the other after all joints are made up, final turn.

No bell and spigot cast iron pipe with poured or caulked joints shall be used under air pressure, and all pipe liable to corrosion, where underground or exposed to chemical fumes, for example, shall be painted or otherwise so treated as to reduce to a minimum this deterioration, which, with the pipes unprotected, might soon cripple the system. To further safeguard the piping against corrosion, it is advised that after the joints are made up and before the second coat of paint is applied, the pipe should be wrapped tightly with burlap and burlap painted on outside; also that the pipe should be laid in a box or split tile conduit for still additional protection.

59. Flanged Dummy—A flanged section of pipe with drain outlet same size as dry-pipe valve, to take the place of dry-pipe valve in case of repairs, should be provided for each type and size installed.

60. Alarm Attachments—A dry-pipe valve should be provided with either or both mechanical and electrical alarms, installed in accordance with the requirements for alarm valves (Section G). A dry-pipe valve hould be fitted with an approved alarm testing device, this to be connected with water supply so that alarms may be tested without disturbing main gate or air system. When a dry pipe valve is located on the system side of an alarm valve, the actuating device of the alarms for the dry-pipe may be connected to the alarms on the wet-pipe system.

Pressure gauges should be provided as called for in Section F, Rule 40.

GRINNELL DRY-PIPE VALVE

Model No. 12

(No longer manufactured)

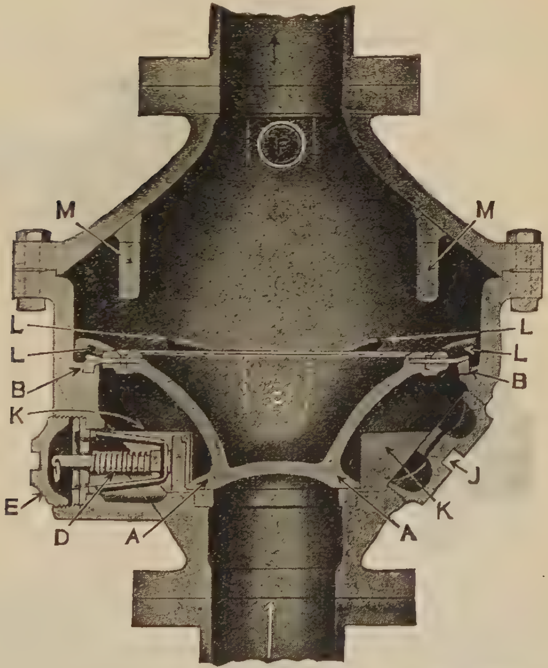


FIG. 122. NAMES OF PARTS: A, Water valve disc. B, Air valve, rubber ring on block tin seat. C, Connection to automatic drain. D, Latch to prevent valve A from reseating after it has once opened. E, Plug to permit access to latch D. J, Hand-hole plug for access to valves A and B. K–L, Guides for valves A and B. M, Stops to limit movement of valve.

GRINNELL DRY-PIPE VALVE

Model B

(No longer manufactured, Model A is similar to Model B)

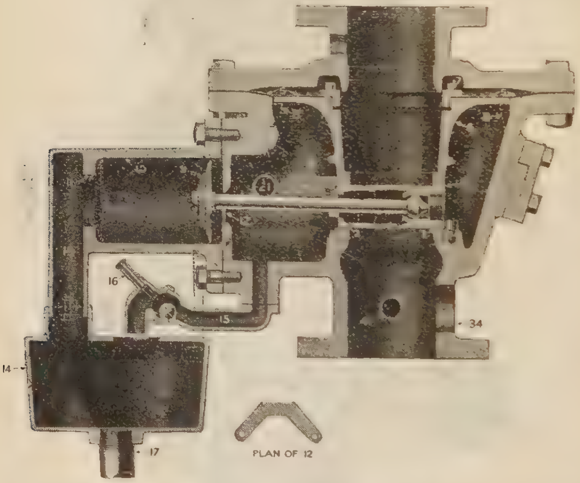


Fig. 123. Names of Parts: 1, Metal plug or gate with water seat (2) and air seat (3). 5, Flexible metal diaphragm, clamped between the two parts of valve body. 6, Air valve casting carried by diaphragm (5). 9, Piston which draws gate (1) from the waterway when valve operates. It fits loosely in the copper and tin-plated cylinder (10). 11, Drain opening which is closed by piston (9) when valve operates. 12, Support for rod of piston (9). 13, 14, 17, Drip chamber and pipe. 15, Ball drip or drain with plunger (16) to test or release ball drip.

GRINNELL DRY-PIPE VALVE

Model C

(No longer manufactured)

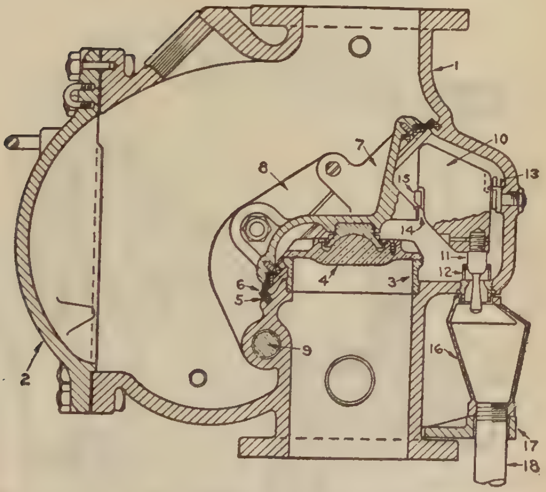


FIG. 124. NAMES OF PARTS: 1, Valve body. 2, Cover plate (some valves of this type have a concave cover plate). 3, Bronze water seat. 4, Bronze clapper which closes water seat. 5, Babbitt air seat. 6, Rubber ring or diaphragm. 7–8–9, Casting, arm, and pin. 10, Latch weight which prevents reseating. 11, Drip valve which closes when valve operates. 16, Drip funnel.

GRINNELL DRY-PIPE VALVE

Model D

(Grinnel Co. Inc.)

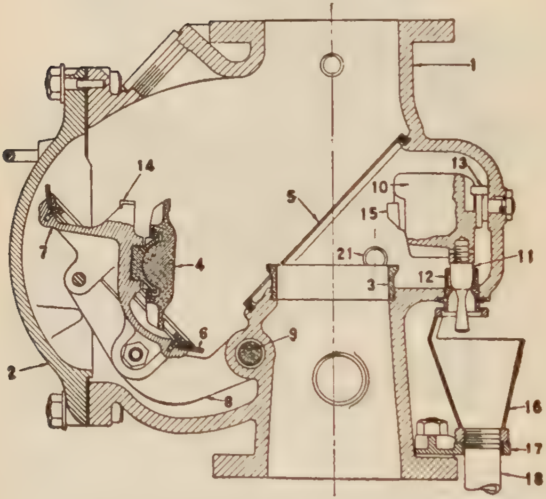


FIG. 125. DESCRIPTION: Type D is very similar to Type C and the same description applies. The throat of Type D is restricted in size and only 3-inch and 6-inch are manufactured the latter being used for 4-, 5-, and 6-inch supply pipes.

GLOBE DRY-PIPE VALVE

Model 5

(Globe Automatic Sprinkler Co.)

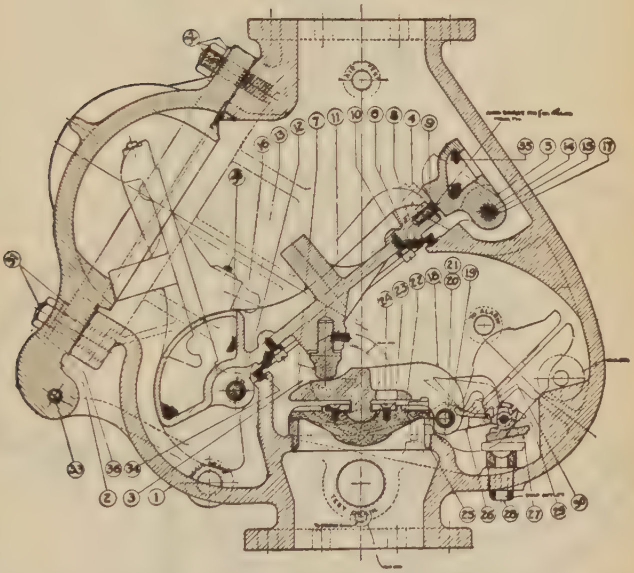


FIG. 126. NAMES OF PARTS: 7, Water clapper. 8, Water clapper support. 9, Water clapper cradle. 10, Adjusting screw. 11, Adjusting nut. 14, Adjusting screw pin. 15, Tumbler. 16, Tumbler lever. 19, Intermediate clapper. 27, Air clapper. 30, Auxiliary clapper. 31, Air clapper catch. 33, Trigger. 35, Ball weight. 37. Ball weight pin. 38, Ball weight link.

GLOBE DRY-PIPE VALVE

Semi-Mechanical, Model B

(Globe Automatic Sprinkler Co.)

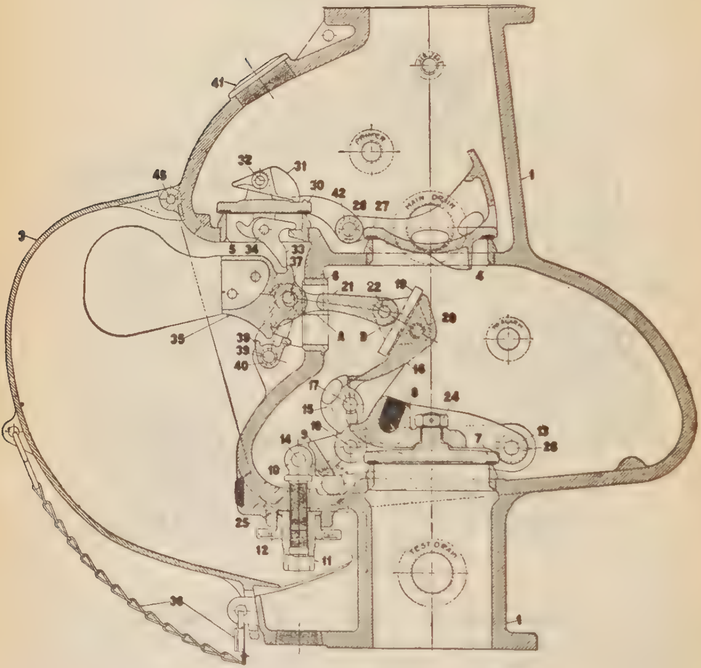


FIG. 127. NAMES OF PARTS: 4, Air clapper. 5, Latch for air clapper. 8, Rubber diaphragm. 22, Water clapper. 18, Compression lever. 30, Latch for water clapper. 28, Drip valve.

INTERNATIONAL DRY-PIPE VALVE

Models 4 and 5

(No longer manufactured)

("Automatic" Sprinkler Corporation of America)

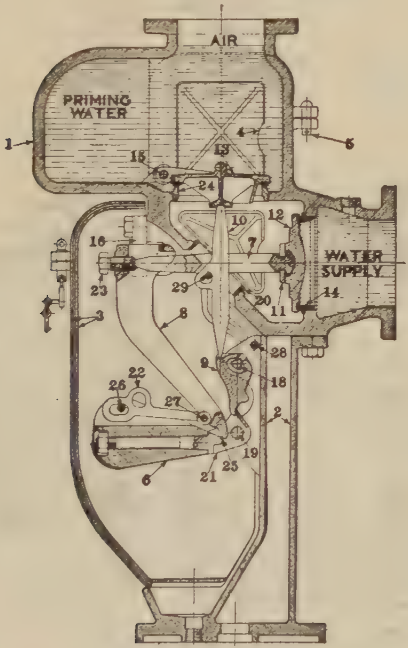


Fig. 128. Names of Parts: 3. Cover. 6, Ball weight. 7, Fork. 8, Hook. 9, Tumbler. 10, Strut. 12, Water clapper. 13, Air clapper. 16, Brack. 18, 19, Hinge pins. 23, Adjusting screw.

MANUFACTURERS' DRY-PIPE VALVE

Model No. 3

("Automatic" Sprinkler Corporation of America)

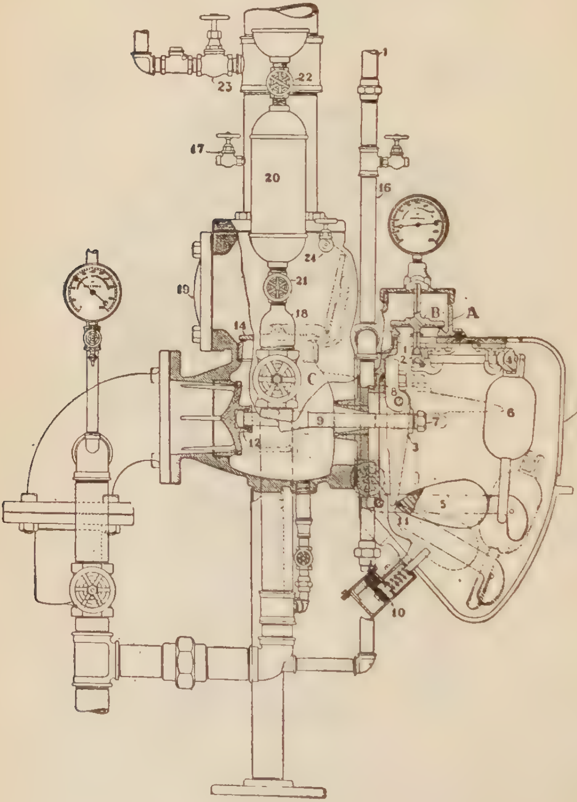


Fig. 129. Names of Parts: 1, Air disc stem. 2, Rolling pin disc. 3, Yoke lever. 4, Releasing lever. 5, Horiontal weight lever. 6, Vertical weight. 7, Adjusting screw. 8, Main hinge. 9, Stem of water valve. 10, Circuit closer. 11, Contact pin. 12, Water valve disc. 13, Main drain. 14, Air clapper. 16, Anti-water column. 17, Air test. 20, Priming chamber. 22, Funnel valve. 24, Priming test.

NIAGARA DRY-PIPE VALVE

Model E

(No longer manufactured)

("Automatic" Sprinkler Corporation of America)

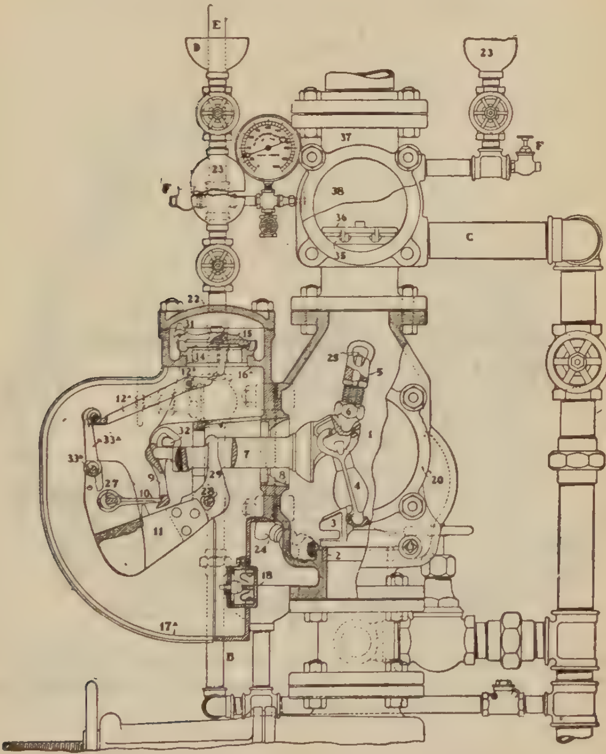


Fig. 130. Names of Parts: 3, Water clapper. 4, Lower toggle strut. 5, Upper toggle strut. 6, Compression screw. 7, Plunger. 9, Fulcrum lever. 10, horizontal strut. 11, Weight. 12, Trip lever. 15, Air pot clapper. 18, Electric circuit closer. 23, Priming chambers. 24, Ball drip. 25, Upper strut pins. 27, Horizontal strut pin. 28, Weight pivot pin. 29, Weight lever. 33A, Weight hook. 36, Air disc.

ROCKWOOD DRY-PIPE VALVE

Model A

(Rockwood Sprinkler Co.)

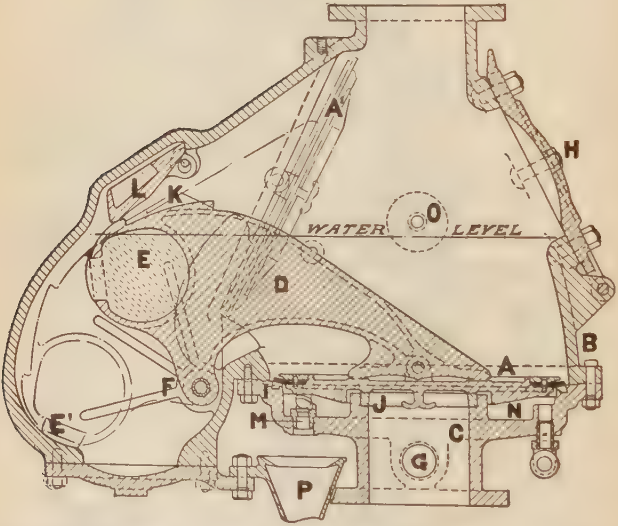


Fig. 131. Names of Parts: A, Air and water disc. D, Lever. E, Weight. F, Hinge. J, Water Seat. L, Latch. N, Intermediate space between air and water seats. P, Drain.

F. P. C. DRY-PIPE VALVE

Model A

(Fire Protection Co.)

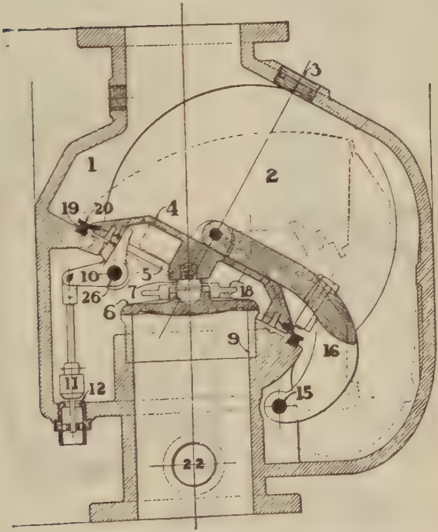


Fig. 132. Names of Parts: 4, Air clapper. 6, Water clapper. 9, Water valve seat. 10, Rocker arm latch. 11, Drip valve. 16, Link arm. 19, Air valve seat. 20, Rubber ring.

F. P. C. DRY–PIPE VALVE

Model K. M. E.

(Fire Protection Co.)

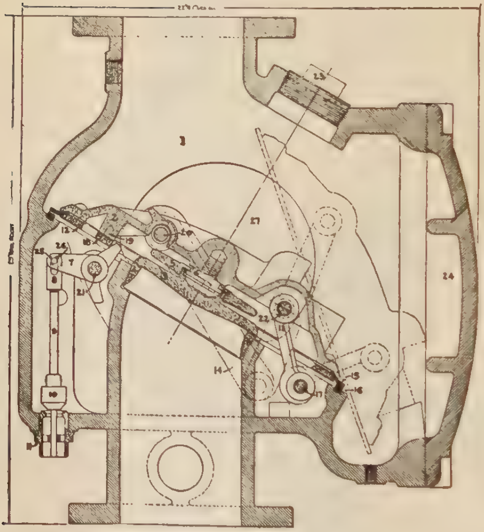


FIG. 133. NAMES OF PARTS: 2, Air clapper. 3, Water clapper. 7, Rocker arm latch. 10, Drip valve. 13, Short link. 14, Long link. 15, Rubber ring. 16, Air valve seat.

GRINNELL DRY-PIPE VALVE ACCELERATOR

(Grinnell Co., Inc.)

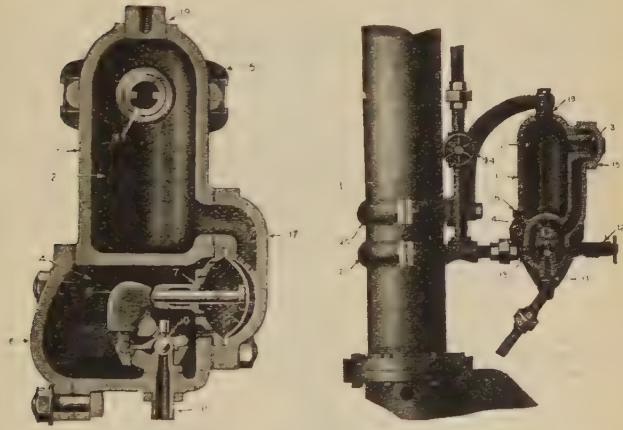


FIG. 134. DESCRIPTION: 2, Upper chamber. 3. Restricted orifice (this can be removed for examination or test by taking off plate 15). 4, Lower chamber. 5, Rubber diaphragm which actuates plunger 6, strikes weight 8, and this in falling strikes and opens ball valve 10. Air from the sprinkler system enters at 13, and is controlled by valve 14. Pipe 11 is the outlet from accelerator and leads to the intermediate chamber of a differential type of dry valve. When a sprinkler operates the pressure is reduced slightly in 4, but is not reduced in 2. This causes a movement of diaphragm 5, and air escapes from valve 10, and creates a pressure in the intermediate chamber and trips the dry valve. With Grinnell Dry-Pipe Valves, Types A and B, pipe 11 leads to an auxiliary device, so designed that the air pressure acting on the diaphragm, opens a valve and allows water pressure from the water supply to enter the dry valve chamber and trip the dry valve.

A slight sudden drop in air pressure will trip or open both the accelerator and the dry-pipe valve; therefore, greater care is necessary in drawing off or blowing out water of condensation or slow drainage, in testing for water column and in reducing high air pressure. The only safe way to make these tests is as follows:

1. Close Globe Valve 14 which controls the accelerator.
2. Remove large head plug 18 to release the air pressure in upper chamber 2 of the accelerator.
3. Blow out water at each test, vent or drain valve, or release the excess of air pressure in the system in the usual manner.
4. Replace plug 18 and then open wide Globe Valve 14 and strap or seal it open.

Directions for Setting Accelerator

If the dry-pipe valve has opened, close the main gate valve and drain the system in the usual manner, and then close Globe Valve 14 (Fig. B).

Set and prime the Dry-Pipe Valve, pump air into the System, close the Main Draw-off Valve, and partially open the Main Gate Valve in the usual manner. See that both the Air and the Water Seats of the Dry-Pipe Valve are tight, then close the Main Gate Valve.

With the Globe Valve 14 closed, open triangular Hand-Hole Plate 16 (Fig. A) of the Accelerator. Remove Plug 18 (Fig. B) and see that there is no water in Upper Chamber 2. Push Diaphragm Rod 6 (Fig. A) into position as shown, then replace Plug 18.

Partially open Globe Valve 14 and see that there is no water in the ¾-inch connection from the System. Then close Globe Valve 14.

Carefully clean Ball Valve 10 (Fig. A) and its Seat 11, lift Lead Weight 8 to a vertical position, and replace Hand-Hole Plate 16. Never apply grease, tallow, or any other oily substance to Ball Valve 10 or Seat 11.

With Globe Valve 14 still closed, prime Ball Valve 10 by opening Priming Valve 12 (Fig. B) and slowly pouring water into the Priming Cup attached until no more water will enter the Accelerator. (As there is no vent to the Accelerator, priming water will enter same very slowly. Nearly a pint of water is necessary to properly prime Ball Valve 10.) Tightly close Priming Valve 12 and open Globe Valve 14.

See that Ball Valve 10 is tight, otherwise the water or air will come out at Ball Drip on Dry-Pipe Valve. If Ball Valve 10 is not tight, close Globe Valve 14 and again clean Valve 10, etc. If Ball Valve 10 is tight, open wide the Main Gate Valve under the Dry-Pipe Valve and the Accelerator and the Dry-Pipe System are in service.

Before Leaving the Accelerator

1. Be sure that Plug 18 is screwed into place.
2. Be sure that no water or air appears at Ball Drip on Dry-Pipe Valve.
3. Make sure that Globe Valve 14 is opened wide and sealed or strapped.

GLOBE DRY-PIPE VALVE ACCELERATOR

(Globe Automatic Sprinkler Co.)

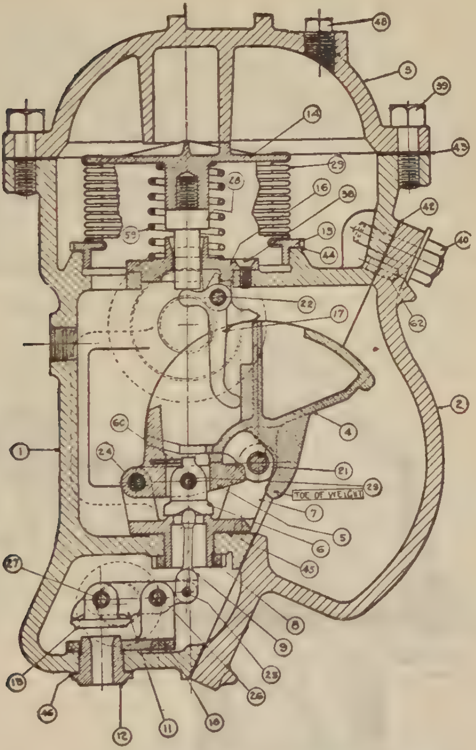


FIG. 135. DESCRIPTION: The Globe Accelerator consists of a cast-iron body that encloses three chambers having communicating passages. The topmost chamber is separated from the middle chamber by a flexible partition, called a "sylphon" No. 29. The "sylphon" has a free vertical movement of ¼ inch, but is held to its extended position by a spring No. 59. The topmost chamber has a restricted passage or "platinum eye" orifice, not shown in cut, by which air passes back and forth to the middle chamber containing the levers, weight, and associated parts. The middle chamber has a piped connection with the system by which the system air pressure is maintained in it, and this pressure filters to the upper chamber through the restricted orifice, thereby equalizing the pressure on each side of the "sylphon." The bottom chamber, normally, has no pressure in

it beyond the "atmospheric pressure that exists in the "intermediate" chamber of the Dry Valve—and the intermediate chamber of Dry Valve and bottom chamber of Accelerator are connected by piping. This piping, normally, conducts any leakage of Dry-Valve seats to the orifice No. 12, where it is discharged into the drain pipe.

When a sprinkler operates the pressure is reduced in the Middle Chamber more rapidly than pressure can fall in the Upper Chamber, because the air cannot escape through the "platinum eye" at the same speed. The trapped air in the Upper Chamber, therefore, expands and overcomes the tension on the Spring No. 59, tending to force the sylphon downward and this force, reacting on the bell crank lever overturns the Weight No. 4.

When the Weight falls, the Toe raises the Main Valve Lever No. 5, thereby opening the passage between the Middle Chamber and the Bottom Chamber, which is normally closed by the Main Valve No. 6. The Drain Opening No. 12 is simultaneously closed, when the Main Valve No. 6 is raised from its seat, by the upward movement of the Release Rod No. 9, allowing the Drain Valve No. 13, and associated parts, to close the Drain Opening No. 12. This permits air pressure equivalent to the system pressure to build up in the Atmospheric Chamber of the Dry-Pipe Valve and trip the Valve.

"AUTOMATIC" EXHAUSTER FOR DRY SYSTEMS

("Automatic" Sprinkler Corporation of America)

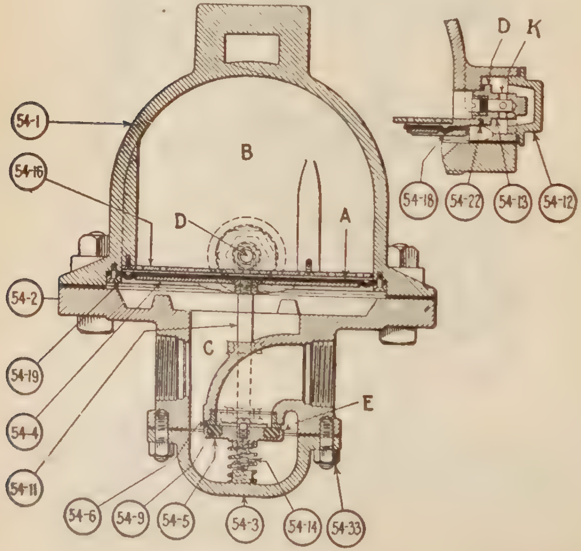


FIG. 136. DESCRIPTION: The purpose of the Exhauster is to hasten the operation of the dry-pipe valve after the opening by fire of a sprinkler

head. The device accomplishes this result by opening at the dry valve a 2-inch discharge that quickly dispels the air pressure, bringing it down to normal operation of the dry-valve, and is unlike other devices of this general class that hasten the tripping point of the valve, regardless of air pressure.

When a dry-pipe system is in operative condition, air of equal pressure is present both below and above the diaphragm "A." This diaphragm separates chamber "B" and "C" with a communication through restricted by-pass "D," the detail of which is shown in Fig. 2.

When a sprinkler head opens, the air pressure in the piping system is quickly reduced and the air pressure in chamber "C" which is directly connected with the piping system immediately feels the reduction, while chamber "B," retains its pressure because the air cannot quickly flow out through the restricted by-pass "D"; the higher pressure remaining in "B," being stronger than "C," expands diaphragm "A," pushing it downward, opening valve "E," allowing the air from the piping system to flow into the portion of the dry valve known as the intermediate chamber from which it escapes into the atmosphere.

This escape of air (a full flow of a 2-inch pipe) plus that through the open sprinkler head quickly dispels the air, allowing the pressure to drop to the normal tripping point of the valve. When the dry valve trips, the outlet to the atmosphere chamber from which the air was allowed to escape is closed, preventing the escape of water.

The Exhauster must always be located above the priming water level in the dry-pipe valve so that air only will enter when the system is set dry.

Before the Exhauster is installed remove cover 54-3 and examine Chamber "C" and disc "E." If any foreign matter is found remove it, as "C" and "E" must be free from obstruction. Next remove plug 54-12 and see that openings "K" in vent plug are not obstructed. Replace plug 54-12 and cover 54-3, making sure that gasketed joints are tight.

Instructions for Setting.

Proceed to drain dry-pipe system as explained on Dry-Pipe Valve Instruction Card—in addition to which back out plug 54-12 and vent housing 54-13, allowing any water that may accumulate in "B" to empty itself. Remove any foreign matter from the holes "K" in vent housing and from the metal cloth screen on the threaded end. After water has drained out, replace vent housing 54-13, screwing same to its seat against the gasket 54-22. This joint must be absolutely tight. Replace plug 54-12, making sure that a tight joint is made and proceed to set the dry-pipe valve as outlined on dry-pipe valve Instruction Card.

Although the "Automatic" Exhauster is designed primarily for use on the International Dry-Pipe Valve, it can be applied to any other type of dry-pipe valve by means of an "Automatic Exhauster Adaptor." The Adaptor is a special diaphragm operated valve, which closes the discharge outlet when water enters sytem.

DELUGE VALVE

("Automatic" Sprinkler Corporation of America)

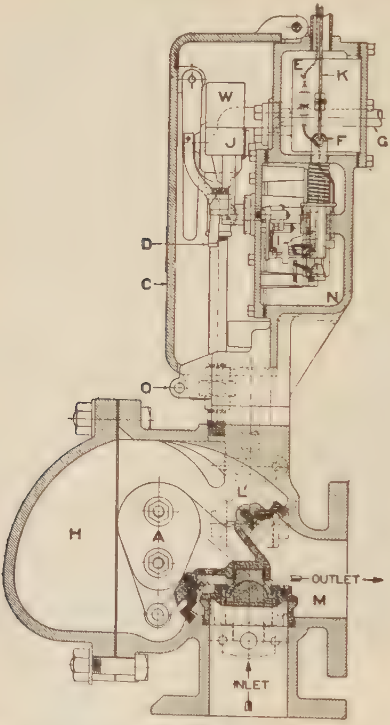


FIG. 137. DESCRIPTION: Designed for use under special conditions of extreme hazard, and is recommended by the makers for systems protecting film vaults, manufacture and storage of pyroxyline products, munitions, making water curtain automatic, small sections ordinarily on cold weather valve, cold storage, japanning ovens, grinding mills, and cotton pickers.

This apparatus differs from standard sprinkler systems as follows:

It operates on the "Rate of Rise" principle in fire detection, giving extreme quickness of operation. There is no air pressure carried on the system side and valve acts intantly. In a system with sealed heads, advance notice of the fire is given by an alarm due to the "Rate of Rise" detection, sufficiently in advance of a head opening to permit first aid to extinguish the fire without water damage. Water is on the sprinkler when it does open.

The valve proper consists of a differential check valve similar to a dry valve with a differential of 2.5 to 1. There is a water valve seating horizontally and an upper valve, corresponding to the air valve in a dry valve, seating at an angle of about 45 deg. The outlet pipe takes out of the intermediate space instead of above the upper valve as in a dry valve.

There is a chamber above the valve which is normally filled with water under the system pressure by means of a by-pass containing a restricted area.

The device is operated by one or more Release devices similar to the Lowe Release Box, each covering an area of 1,000 to 1,500 sq. ft. These consist of a closed receptacle containing aid and a slow leak element. When heated the air expands slightly and this increase in pressure is transmitted through a small pipe to a diaphragm and releasing mechanism I, mounted in a waterproof compartment N at the valve. The tripping device releases the weight W which drops and opens the relief valve J, thereby reducing the pressure in the chamber H above the valve. The water pressure then forces the valve open and water flows to the system.

The valve has a manual as well as an automatic tripping attachment.

The sprinkler heads on the system may be either automatic or open, or a combination of both, and normally there is simply air under atmospheric pressure in the pipes. In hazardous places, the pipe sizes may be increased in size and the spacing made closer than normal. The usual electric and rotary gong may be connected direct to the discharge pipe.

CHAPTER 33

SYPHO CHEMICAL SPRINKLER SYSTEM AND SERVICE

(“Automatic” Sprinkler Corporation of America)

1. It is recognized that a large percentage of fires in properties equipped with automatic sprinklers are extinguished or held in check by one or two sprinklers. This is especially true with properties where the conditions are not favorable to a quick spread of fire as in the so-called non-hazardous properties such as hotels, schools, office buildings, and some classes of mercantile and manufacturing properties with relatively slow burning contents.

2. It is further true that in localities where there is no adequate city water supply available for a supply to automatic sprinklers, the cost of obtaining good water supplies such as a tank or pump may be prohibitive for the smaller and less hazardous properties.

3. The Sypho Chemical sprinkler system was designed for properties where the conditions are such that not more than one or two sprinklers would probably open in a fire and where a satisfactory water supply for the regular sprinkler system is not available.

4. The regular automatic sprinkler head and standard spacing is used. Smaller feed pipes are provided as the system is designed to feed not over three sprinklers. The supply is a tank which is generally of two hundred gallons capacity, and this tank is nearly filled with a solution of bicarbonate of soda. There is also an acid container and means by which, when a sprinkler opens, this acid is syphoned into the soda solution.

5. In general principle, therefore, this is a chemical fire extinguisher of the well-known soda and acid type, connected to a specially designed sprinkler system. The sprinkler pipes are filled with a calcium chloride non-freezing solution.

6. This system has been approved as a whole by the Underwriters' Laboratories and this approval not only includes all mechanical features but also a maintenance and inspection service.

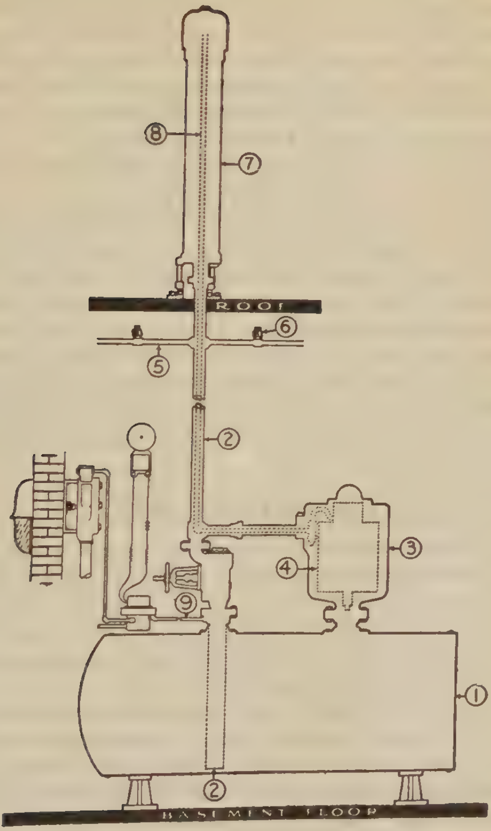


Fig. 138. Sypho Chemical System.
(Courtesy of "Automatic" Sprinkler Corporation of America)

7. The approval provides that the system shall only be used where the conditions are such that not over 2 or 3 sprinklers are likely to operate, for it is evident that, with the very limited supply of extinguishing liquid, the tank would be drained very soon if several sprinklers operate. Great care must be exercised in the selection of properties, and there have been cases where this system has not taken care of the fire because the hazard was too severe, and a considerable number of sprinklers opened.

8. The system has alarm attachments so that prompt notification should be given if a sprinkler head operates.

9. The Sypho Service is rendered by "Automatic" Sprinkler Corporation of America and comprises its approval of the plans of the equipment proposed for the customer, rigid specifications for installation, inspections to insure compliance with the specifications, and periodical inspections of the System after installation, all to make sure, through a Service of Supervision, that the installing company furnishes a proper equipment to meet the needs of the individual case, that the System is properly installed, and that the installing company maintains the equipment in its original high state of efficiency.

NAMES AND FUNCTIONS OF PARTS.

10. In connection with the following description, see Fig. 138.

1. Main retaining drum of capacity of 200 gallons, containing bicarbonate of soda solution.

2. Discharge pipe through which liquid is forced out of retaining drum. In the discharge pipe just above retaining drum is a special valve housing containing:

a—A valve that is locked in the open position while the system is in normal condition, but is automatically unlocked by the generation of pressure in the piping. The valve can only be closed after the system has been put in fire condition. This feature prevents the malicious or accidental closing of the valve.

b—A check valve which normally prevents the liquid in the system from running into the retaining drum.

3. Triple syphon dome containing three charges of sulphuric acid, the primary, the secondary, and the main or sustaining and pressure regulating charge.

4. Outline of acid containing syphons.
5. Automatic sprinkler piping.
6. Automatic sprinkler head.
7. Expansion chamber at top of riser pipe.
8. Suction pipe inside discharge pipe connecting expansion chamber with primary charge acid syphon.
9. Pressure pipe connection with electric and mechanical alarms. The mechanical water motor alarm is operated by the building water supply.

METHOD OF OPERATION.

11. The successive steps which will take place in very rapid succession when an automatic sprinkler head fuses, are as follows:

a—The initial flow of water (or of water and a non-freezing chemical) causes a drop in the liquid level in expansion, Chamber 7.

b—This drop in level causes a suction which is transmitted through 8 to primary acid charge in triple syphon dome.

c—This suction causes the primary acid charge to overflow into the secondary acid charge, thus automatically starting the secondary syphon and emptying the contents of both syphons into the bicarbonate of soda solution in the retaining drum 1. This creates pressure and discharges contents of 1 through the sprinkler or sprinklers.

d—The gas pressure produced enters the interior of the main acid syphon until a pressure equilibrium is established. Upon the dropping of pressure in the retaining drum, acid from the main syphon is discharged into the retaining drum and the pressure thereby raised. The result is an effectively sustained and remarkably uniform discharge pressure.

e—When the fire is out, valve at base of riser may be closed to prevent additional water damage.

CHAPTER 34

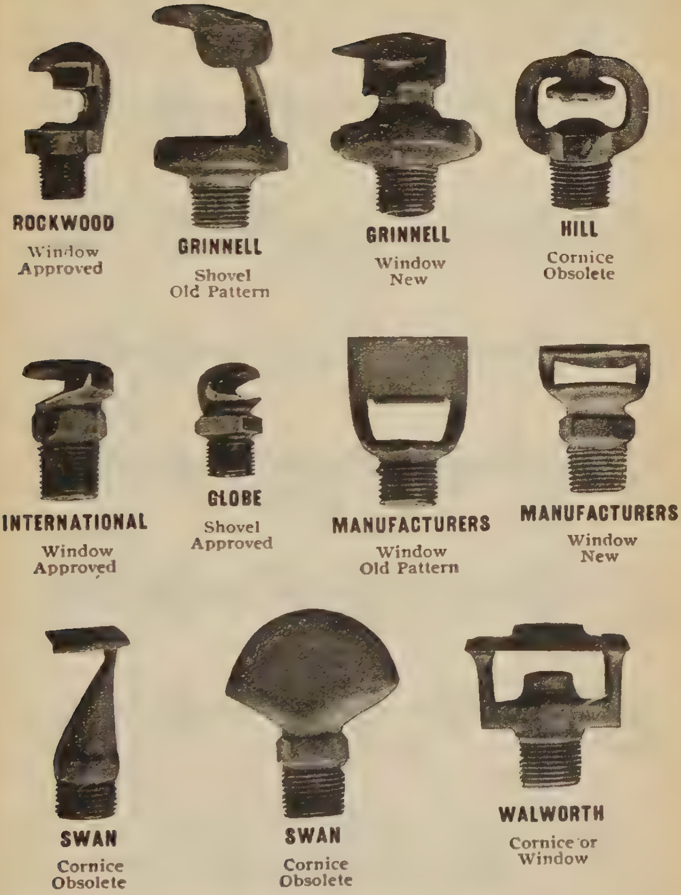
OPEN SPRINKLERS

1. The use of a water curtain on the outside wall of a building probably antedates automatic sprinklers. In the early years of automatic protection, the sprinkler head with the strut removed or a similar device was used on the peak of combustible roofs and at the eaves of buildings, especially wooden buildings. These open sprinklers were placed eight to ten feet apart and fed by piping with pipe sizes the same as for automatic sprinklers or larger where a number of open sprinklers were fed from one end. These sprinklers were arranged or designed to distribute the water over the roof or side wall and protect against fire in neighboring or adjacent properties.

2. Later on, special types of open sprinklers were designed to protect window openings in brick walls, the sprinkler being placed near the top of the window, and the water discharging against the glass, and covering the entire window with a sheet of water.

3. In all cases the water is turned on when needed and generally the controlling valves are located in the basement or first story. The water supply is generally independent of the automatic sprinkler system and usually the outside or open sprinklers are connected to the city main as it is necessary to have available a considerable volume at good pressure. Tanks are not generally satisfactory because of the limited supply of water, but pumps can be used if there is plenty of water for the pump.

4 Almost all of the older types had one half inch openings, the same as the automatic sprinkler, but the modern types are $\frac{3}{8}$, $\frac{5}{16}$, and $\frac{1}{4}$ inch orifice. (See Rules following.) With these modern types, considerably less water is needed for effective service, and ten to fifteen gallons a minute is the average discharge for a modern system of fair size. In determining the necessary supply for the side of a building with a considerable number of average



ROCKWOOD
Window
Approved

GRINNELL
Shovel
Old Pattern

GRINNELL
Window
New

HILL
Cornice
Obsolete

INTERNATIONAL
Window
Approved

GLOBE
Shovel
Approved

MANUFACTURERS
Window
Old Pattern

MANUFACTURERS
Window
New

SWAN
Cornice
Obsolete

SWAN
Cornice
Obsolete

WALWORTH
Cornice or
Window

Fig. 139. Open Sprinkler Heads.

sized windows, not less than ten gallons per window per minute should be provided.

5. Where this kind of protection is desired for more than one side, or where there are a large number of sprinklers on one side,

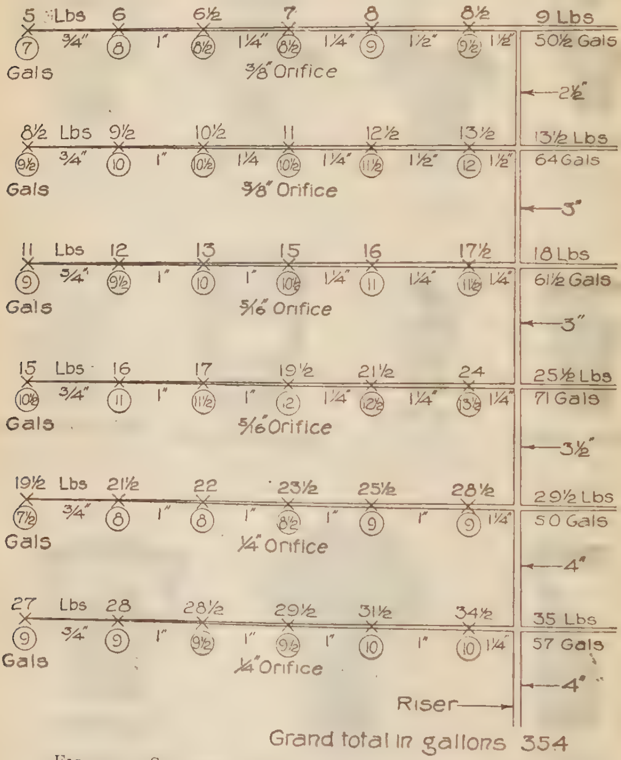


FIG. 140. STANDARD OPEN SPRINKLER SYSTEM DIAGRAM.
(Only one half of system shown.)

the system should be divided vertically with separate shut-off valves for each section, not over 50 heads per valve.

6. In some cities where street mains are large and pressures high, open sprinkler systems can often be used without having any serious effect on the water supply needed for hose streams and for automatic sprinklers. It must be realized, however, that the best city water supplies may be seriously impaired at time of conflagration. If the water supplies are of limited volume, care must be taken to limit the number and use of open

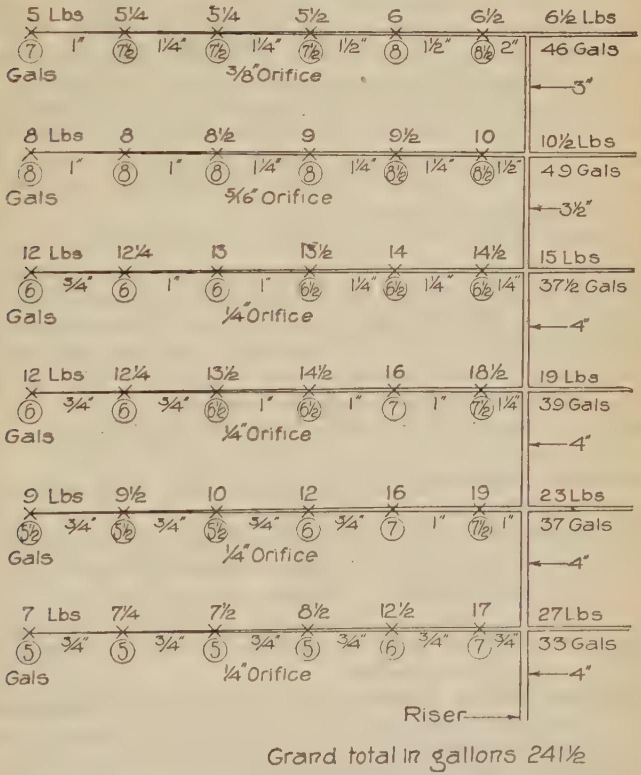


FIG. 141. EXPERIMENTAL OPEN SPRINKLER SYSTEM DIAGRAM.
(Only one half of system shown.)

sprinklers so as not to overtax the water supplies and cripple or render ineffective fire protection of greater value.

7. Outside sprinklers on openings in brick walls have shown excellent results in a large number of fires, including the Baltimore and Toronto conflagrations. While not the equivalent of wire glass windows or shutters, experience shows that the water curtain will keep the window intact even with moderately severe exposure fires.

8. The rules reprinted below are found in the same National Board booklet as the rules covering automatic sprinklers. Buildings having brick or other masonry walls, and frame buildings which may have to be wet down in their entirety, are covered.

9. Fig. 140 shows the test results on a system erected in accordance with the rules, and Fig. 141 an experimental system which a committee of the National Fire Protection Association tested in 1907. The Factory Mutuals make use of a system practically identical with this experimental system.

10. Open sprinkler systems have by experience been found easily to clog with dirt, scale, mud, insects, etc., and periodic tests, not less than one per year, are therefore essential. More frequent tests, while desirable from a fire protection standpoint, are objectionable because of the soiling of building walls, possible leakage through windows, and interference with work within the building and with traffic on streets.

11. When open sprinkler systems are tested, it is desirable to do the following:

a—Make certain that all windows are tightly closed so as to avoid leakage.

b—Ascertain that water from open sprinklers will not run into basement, where it may damage stock and where, under the worst conditions, it might even put out fire under boilers if these are located at a low point. Curb walls around cellar window openings and shields to deflect water may be necessary.

c—Rough diagram of the sprinkler system should be prepared and record made on this of any sprinklers which fail to operate properly.

d—Promptly after completion of tests, clogged heads should be removed, cleaned, and replaced.

e—All portions of a more extensive system which might be used at the same time should be tested out simultaneously to make certain that the water supply is ample.

f—It should be ascertained that at night and at other times when plant is not in operation, watchmen, firemen, or others in building understand the operation of the sprinkler system, and particularly that they will not put it into operation until windows are tightly closed and the likelihood of internal water damage is reduced to a minimum.

12. See Fig. 139 for illustrations of open sprinklers of different types, and of both approved and unapproved designs.

NATIONAL BOARD RULES

(Automatic Sprinkler Rules—1922 Edition)

13. The regulations of the National Board of Fire Underwriters governing the installation of open sprinkler requirement are found in the same booklet as those pertaining to automatic sprinkler equipment and are as follows:

SECTION L—OPEN SPRINKLERS

(For Protection against Exposure)

WINDOW SPRINKLERS

85. Discharge Orifice—Where there is but one horizontal line of window sprinklers, each head should have a smooth bore tapering outlet with an unobstructed orifice ⅜-inch in diameter. Where the conditions call for more than one line the following size orifices should be used:

	2 lines.	3 lines.	4 lines.	5 lines.	6 lines
Top line.	3/8-in.	3/8-in.	3/8-in.	3/8-in.	3/8-in.
Next lower.	5/16-in.	5/16-in.	3/8-in.	3/8-in.	3/8-in.
Next lower.		1/4-in.	5/16-in.	5/16-in.	5/16-in.
Next lower.			1/4-in.	5/16-in.	5/16-in.
Next lower.				1/4-in.	1/4-in.
Next lower.					1/4-in.

Where there are over six horizontal lines of windows it may be preferable to omit sprinklers on the first story or possibly even on the second story, but if over six lines are used the system should be divided horizontally with independent risers, and in some cases this may be desirable even where six lines or less are used. Thus where eight lines would be required, the four upper lines should be on one riser according to the above table and the four lower lines similarly arranged on another riser. Where over six lines are used, size of orifice should be left to the Inspection Department having jurisdiction.

Each open sprinkler head should be clearly marked on the outside as to whether ⅜-inch, 5/16-inch or ¼-inch orifice.

Where windows are 3 feet or less in width a size smaller orifice than required by this rule may be used, except that in no case should a size smaller than ¾-inch be used.

86. Pipe Sizes—No branch line should have over six sprinklers where central riser system is used. Where gridiron system (i. e., a riser at each side with sprinklers located on the connected pipes) is used, the lines between side risers should not have over twelve heads. Branch line pipe sizes should be as follows, this applying with either central riser or gridiron system. With the gridiron system the end head is considered as being the one directly in the center (or on either side of center if the number on line be even).

(*a*) For ⅜-inch orifice: one head on a ¾-inch pipe; two heads on a 1-inch pipe; four heads on a 1¼-inch pipe; six heads on a 1½-inch pipe.
(*b*) For 5/16-inch orifice: one head on a ¾-inch pipe; three heads on a 1-inch pipe; six heads on a 1¼-inch pipe.
(*c*) For ¼-inch orifice: one head on a ¾-inch pipe; five heads on a 1-inch pipe; six heads on a 1¼-inch pipe.

Where heads are over twelve feet apart special pipe sizes in excess of the requirements given below should be used.

87. Risers and Feed Mains—Central feed risers.

1½-inch.	Not over 6 heads.
2 -inch.	Not over 10 heads.
2½-inch.	Not over 20 heads.
3 -inch.	Not over 36 heads.
3½-inch.	Not over 55 heads.
4 -inch.	Not over 72 heads.

For gridiron side feed risers, use the same sizes counting to the center of each line. If number on line is odd the center head may be neglected in figuring size of side risers, except that pipe feeding both risers must take into account all sprinklers which it feeds. Where feed main (including risers to the first branch line) is over twenty-five feet in length, feed main should be at least a size larger than the tables require. Where there is more than one riser, size of feed mains should be determined by the Inspection Department having jurisdiction but should never be less than the full equivalent of the two largest risers.

At all dead ends a tee instead of an elbow should be used and a piece of pipe 6 inches long with brass plug in end should be screwed into tee to form a pocket for collecting dirt.

Where sprinklers run on two adjoining sides of a building with separate controlling valve for each side, the end lines should be connected together with check valves so located that one head around the corner will operate when valve is opened. The intermediate pipe between the two check valves shall be so arranged as to drain properly.

Strainers of a standard type should be installed at base of risers, or in connections to same. Strainers should be so located as to be easily accessible for cleaning.

88. Pipe—Galvanized wrought iron (or other standard) pipe should be used for the equipment as far back as the cast iron pipe. All galvanizing of pipe should be done in a careful and thoroughly workmanlike manner.

Pipe should be securely supported in a manner fully equal to that required for automatic sprinklers.

All pipe should be carefully inspected before being installed.

89. Valves—Where central feed risers are used each should have a controlling valve. Where side feed risers are used they are to be connected together at bottom and one valve so located as to control the two risers. Valves should be of standard type as required for automatic sprinkler systems. Distinct marking of each valve by letters not less than one-half inch high is required. Riser valves should be so located as to be easily accessible, preferably in first story.

90. Drainage—All pipes and fittings should be carefully arranged and pitched so as to thoroughly drain the entire system as far back as the inside riser controlling valve. Drip pipes shall be not less than 1 inch in size.

91. Location and Number of Sprinklers—For windows not exceeding five feet wide one sprinkler should be placed at center near top, so located that the water discharge therefrom will thoroughly wet the upper part of the window, and by running down over the sash and glass wet to the greatest extent the entire window. Where windows are over five feet wide, or where mullions interfere, two or more heads should be used; this, together with size of orifice, should be determined by the Inspection Department having jurisdiction, it being understood that two ¼-inch heads are approximately the equivalent of one ⅜-inch.

For windows five to six feet wide one sprinkler may be used by special consent of the Inspection Department having jurisdiction.

92. Water Supply and Control—Supply to open sprinklers should be town waterworks, standpipe, pump or fire department connection, but never pressure or gravity tank used to supply automatic sprinklers, except that such gravity tank may be used in case additional capacity is provided.

Where water supplies feed other fire protective appliances, such as automatic sprinklers or hydrants, system should be so arranged that there is no danger of impairing the efficiency of such other devices, and water supply should be of sufficient capacity to adequately feed such appliances even with the open sprinklers in operation. Supply should be of sufficient capacity to feed all sprinklers designed to be operated at one time and maintain not less than 10 pounds pressure at top of riser for a length of time depending on conditions, but not less than 60 minutes. Where fire department connections are used they shall be located so as to be safe from the exposing fire, as in the rear of building if exposure is on the front. Where other water supplies are used and it is desirable or necessary to save such supplies for other service in case the open sprinklers are ineffectual, locate a controlling valve or valves outside the building itself and accessible as regards the exposure fire. Such valves may be located in properly cut off valve rooms or pits by special consent of the Inspection Department having jurisdiction. Underground controlling valves should be in approved pits with manhole or be fitted with standard post indicators.

93. Sprinklers—Only such types of window, cornice, side wall or ridge pole sprinklers should be installed as have been standardized for such use.

94. Gauge Connections—Plugged outlets for gauge connections should be provided at the top of each riser and just below the controlling valve of each riser. Such outlets should be piped into the building for the purpose of conveniently attaching a test pressure gauge.

CORNICE, SIDE WALL OR RIDGE POLE SPRINKLERS

(For use in protecting frame buildings, mansard roofs, etc.)

95. Location, Size of Orifice and Number—Where one line only is required, as for the mansard roofs of a brick building or for low frame buildings, the heads should not be less than ⅜-inch orifice and not over eight feet apart on the line. Pipe sizes and arrangement should be the same as for window sprinklers. Where the number of sprinklers and water supplies admit, it may be desirable to use a 7/16 or ½-inch orifice with pipe sizes not less than the following: 1 on 1-inch; 3 or 1¼ inches, 5 on 1½ inches, 8 on 2 inches. Where frame buildings are over two stories high it will be generally necessary to have two or more horizontal lines, preferably one line at each of the upper stories beginning at the eaves line, the heads located over each vertical row of windows where windows are not over eight feet center to center. Size of orifice and pipe sizes should be same as for window sprinklers except by special consent of the Inspection Department having jurisdiction. The value of open sprinklers for frame buildings is much enhanced by the use of wood shutters at all window openings.

Authors' Note—The use of a regular automatic sprinkler head with the strut removed may be accepted for ridge pole and similar duty.

CHAPTER 35

SIGNALING SYSTEMS AND WATCHMAN SERVICE

1. The regulations of the National Board of Fire Underwriters bearing on signaling systems cover the following:

a—Municipal fire alarm systems.
Circuits, current supply, boxes, sounding devices, etc.
Class A: Manually operated systems.
Class B: Automatic repeating systems.
Class C: Automatic non-repeating systems.

b—Signaling systems for the transmission of signals affecting the fire hazard.
Class A: Central station systems.
  Manual fire alarm systems.
  Watchman's time-recording systems.
  Automatic fire alarm systems and Thermostats.
  Automatic sprinkler alarm and supervisory systems.
Class B: Auxiliary fire alarm systems.
Class C: Fire alarm systems with fire drill devices.
Class D: Local systems.
  Automatic journal alarms.
  Watchman's time-recording apparatus.
  Local automatic sprinkler alarms.

Note: Automatic sprinkler supervisory and local alarm systems are covered in chapter 31.

c—Radio signaling apparatus.

2. The signaling systems such as those with which this chapter deals are designed to give absolutely certain service at any time and often under unfavorable conditions. It follows therefore that it is essential that:

a—Only approved apparatus, wire, cables, batteries, and other appliances be used in their installation.
b—Skilled workers be employed in installation work.
c—Competent persons have charge after installation.

d—Periodic inspection and test not only of circuit and transmitting device, but also of the detecting element itself in fire alarm systems, to be made by responsible persons, and records kept for review by municipal authorities, underwriters, and others interested.

3. Auxiliary systems connected with municipal fire alarm systems are naturally under the supervision of the municipal authorities, and many of the better types of private fire alarm systems are leased from operating companies. There has, however, been a steady increase in the number of high grade systems owned and operated by individual plants, and it is no longer true that private systems are, of necessity, of the less reliable open circuit type.

MUNICIPAL FIRE ALARM SYSTEMS AND THEIR AUXILIARIES

4. The section on municipal fire alarm system beginning on page 305 prepared by the engineers of the National Board of Fire Underwriters gives in condensed form the essential facts covering municipal fire alarm systems, telephone service, and radio. No attempt is made in this book to go into details of fire alarm engineering, which is a highly technical subject. The purpose is to set down the services that can be secured from different forms of apparatus and systems, especially for the individual plant or property. It may be mentioned that the use of the word "manual" and "automatic" in paragraph 1 refers to the manner in which a signal received at fire alarm headquarters is relayed to the fire company stations.

5. The necessity of having an alarm of fire transmitted promptly to the fire department by whoever discovers fire would seem to be self-evident, and yet comparatively little attention has been paid to this feature as regards ability to send out the alarm from inside the plant. In a few cases we find that a private city fire alarm box has been installed in a plant, but this is not common. Much ingenuity as well as money has been spent on the fire department house and its appurtenances to save every second possible after alarm has been received, also as regards the city fire alarm system that no delay may be occasioned after alarm box has operated, but when we come to the plant itself we find, as a rule,

no means of using to best advantage the public alarm or the fire department, owing to the fact that whoever discovers fire frequently must waste several valuable minutes in reaching the fire alarm box, which may be several blocks distant and its location not known.

CITY FIRE ALARM BOXES.

6. If the main line box is not within a reasonable distance of a property, it is frequently in order to consider having the city provide a box, even if the cost for it must be defrayed. Occasionally the city authorities will install a box free of charge, especially if it also benefits other property owners in the vicinity, but as a rule the owner is called upon to pay for the box while the city installs it and the necessary circuits without cost to the owner.

SIGNS AND KEYS.

7. In any event, the fire alarm box location should be known at the plant and to this end it is good practice to install a liberal number of signs giving the location of the box and the key. Where the key is not kept under glass at the box, or where the box is not of the keyless type, a key should be secured and kept at the property, preferably at a prominent point, such as red, glass front box near the entrance door. The fire department officials are almost always willing to distribute keys to responsible property owners.

AUXILIARY FIRE ALARM SYSTEMS.

8. Auxiliary fire alarms come under the heading of Private Fire Alarm Systems and form a very valuable adjunct to the municipal systems. Even supposing there is a fire alarm box at the plant, the fire may be located at some distance from the box, as on the top floor of a high building, or in some other more remote structure, necessitating a considerable delay where seconds count. The auxiliary fire alarm system largely eliminates this defect, and its use should, therefore, be encouraged. The system is simple and when properly installed auxiliary boxes are located on each floor or on alternate floors and at such points that not more than 200 ft. will have to be traveled in order to reach a box.

9. The boxes distributed about the premises are connected to the nearest main line one, have glass fronts, and upon this glass being broken and a ring pulled down, transmit alarm to headquarters. Attention is called to the fact that in such a case the fire department does not know the exact location of the fire and that it is necessary, if city box is located at any distance from the plant, to send some one to it to direct the department.

10. Auxiliary systems are generally controlled by operating companies, which install them upon a rental basis, maintain them, and are responsible to the fire department for any false alarms which may be transmitted.

TELEPHONES.

11. The telephone plays a very important part in fire notifications in this country. In many cities, especially the moderate sized ones, the number of alarms received by telephone exceeds those coming over the fire alarm system.

12. Where public protection exists and connections can be obtained to the alarm circuit, it is not deemed good policy for an important plant to depend upon telephone notification alone. It is generally true that less apparatus is sent upon a telephone call for help (still alarm) than when a city box is used.

PRIVATE FIRE ALARM SYSTEMS.

13. For an industrial plant of considerable size and importance, and for schools, hotels, and similar buildings, private fire alarm systems are generally a necessity if prompt response is to be secured from the private fire brigade or immediate exit made by the people whose lives might be jeopardized. There are three fundamental types of private fire alarm systems:

a—Closed circuit electric systems.

b—Open circuit electric systems.

c—Manually operated systems employing whistles and gongs.

14. Sometimes these types are used in combination, as when an electric alarm to the power house causes the whistle to be blown to designate the fire section.

15. The closed circuit electric system is, under ordinary conditions, the best, and it is almost universally used for important plants. Of this type, the following variations can be secured:

a—Strictly local fire alarm systems.

b—Local fire alarm system combined with auxiliary system connected to the city fire alarm circuits.

c—Local fire alarm system combined with central station watchman supervisory system, through which central station the public fire department is called.

d—Local fire alarm system and watchman supervision maintained altogether by the plant.

16. Types "b" and "c" are arranged so that drills can be held without calling the public fire department.

17. Open circuit systems are always local in character.

18. In the following sections are given some details regarding each of these types of systems now available.

LOCAL CLOSED CIRCUIT SYSTEMS.

19. Local closed circuit systems always make use of circuits in which boxes and gongs are in series. Large systems are split into several circuits, and are tied together through the central station. The operation of any box makes and breaks the circuit, each break on the ordinary system releasing the spring wound gong mechanism and causing the gong to be struck by the hammer. By means of differing numbers of notches on the toothed wheels in the alarm boxes, different signals are given for each box or for each group of boxes, as preferred.

20. Closed circuit fire alarm boxes, by virtue of their design and the method of wiring, may be of one of the following types:

a—**Interfering Boxes.** With such boxes the pulling of a second box before the first has completed its rounds may cause a partial or complete loss of the signal.

b—**Partial Non-Interfering Boxes.** With such boxes the pulling of a second box does not interfere with the signal of the first box, but the second one does not send in its own signal.

c—**Full Non-Interfering Boxes.** With such boxes the pulling of two or more boxes does not interfere with the clear and complete sending of each box in the order pulled. These boxes commonly are termed "succession."

21. A sufficient number of electro-mechanical gongs are used to enable them to be heard in those parts of the property which it has been decided to cover. In a school or hotel, the entire building must be covered, but in an industrial plant frequently only those portions where fire brigade members work, the office, the power house, and similar buildings need to be covered. Alarm boxes, however, almost always are scattered over the entire property.

22. On some systems an automatic steam whistle, operated by the alarm circuit, is used and gongs are either entirely or largely dispensed with. Where the whistle is blown manually, a recording tape is generally used to avoid error in repeating the box number on the whistle.

23. To be heard over the noise of machinery, riveting, and other noises, it is occasionally necessary to use electric horns instead of gongs. These usually have a local battery and are set in action by the opening of a relay in the box circuit, the opening of which relay simultaneously closes the horn circuit.

24. Dust and fume conditions in industrial plants must be carefully considered before deciding on the installation of any alarm system or upon the kind to be adopted.

COMBINED LOCAL AND AUXILIARY SYSTEMS.

25. The ordinary auxiliary to the public fire alarm system gives no local indication, except possibly in the office, of the sending in of a call to the public department. It is, however, possible to secure a system that combines local gong notification or automatic whistle operation with the auxiliary features. This is practically the ideal combination of local and public fire notification.

COMBINED LOCAL AND CENTRAL STATION SUPERVISORY SYSTEMS.

26. As in the case of the ordinary auxiliary alarm system, the usual watchman central station supervisory installation, which is combined with a fire alarm notification service, gives no local indication of a fire alarm having been sent. It is, however, possible to secure a combined service giving watchman supervision, fire department notification, and local alarm facilities. If a plant needs a local fire alarm system and has the central station supervisory one in force, it is generally cheaper to have one system rather than two separate systems. It also simplifies matters if every watchman's box is an alarm box, and every alarm box will give simultaneously a public and a local alarm.

PRIVATE CENTRAL STATION SYSTEMS.

27. Private central station systems are arranged to give control over watchmen and the police force, and also complete local fire alarm service. This type of system can be used where central station watchman supervisory operating companies are not in operation or where a plant is large enough to make a private system advisable.

One variation of the private central station system is combining with an automatic telephone call system (to locate persons away from their desk) either a local closed circuit fire alarm system, or local watchman's supervision, or both.

DESIGNATING DISTRICT, BUILDING, OR FLOOR.

28. On an increasing scale, it is becoming the best accepted practice to designate, by means of gong strokes or whistle blasts, where fire has broken out or to which point the brigade is to respond for a drill.

a—With plants made up of a group of buildings, it is customary to divide the property into districts, seldom over 6 in number, show these on maps posted prominently, and have all alarm box signals in each district begin with the same number, as 2-1, 2-2, 2-3, 3-1, 3-2, 3-3, etc.

If a whistle is used to designate the district, the practice is generally to blow a long blast to call attention to the existence of a fire and to follow this by one or more short sharp toots to show the district.

It is, of course, customary for gongs to repeat the signals three or four times, and the same thing should be done with whistle blasts if they are handled manually.

b—Sometimes the alarm system gives the building number, and all alarm boxes in the building send in the same signals.

c—Where buildings are few in number and fairly high, it is customary to indicate the building number and the floor by a code such as that described in "a." To know the floor on which fire has broken out has value in that it permits getting out of the building first those people located above the fire, and the fire brigade knows exactly where to respond.

OPEN CIRCUIT SYSTEMS.

29. Open circuit systems are the oldest and simplest electrical kind and consist of a wiring arrangement whereby the closing of any one of a number of switches, usually of the knife type, will ring one or more gongs located advantageously about the property. It is customary with such systems to use different numbers to indicate the locations of the sending stations. With these systems particular attention has to be paid to battery maintenance, which is vitally important if alarms are to be sent properly. Combining domestic bell batteries with fire alarm ones gives constant test. With the closed circuit type of wiring, failures of the batteries gives a trouble signal, but with all open circuits regular tests are necessary to prove the good condition of the battery.

WHISTLES.

30. Large plant whistles, particularly on power houses, are used to give alarms of fire, frequently through word being transmitted to power house by man who discovers the fire, and occasionally through alarm being received on electric system having indicator in power house.

31. Where a property is sufficiently large to warrant its being divided into various fire districts, the location of the fire can be indicated by the whistle blasts, for example, a long blast and one, two, or more short blasts following long blast.

32. Whistle ropes and pull handles must be readily accessible and a signal chart should be posted before the operator specifying the number of seconds that blasts should continue and the time spacing between blasts. Whistle ropes should be about ¼-in. galvanized iron cables, so secured that there will be no danger of failure at time of fire. Drainage should be provided for whistle pipes so whistle will blow promptly and not first discharge considerable water. That there should be no possibility of condensation accumulating at exposed points where water could freeze and put the whistle out of commission is obvious.

MANUALLY OPERATED STATIONARY GONGS.

33. Manually operated stationary gongs are of value to call men together at reasonably small properties, answering to a certain extent the same purpose as a steam whistle. Usually a single large gong is sufficient. Old locomotive tires and large steel triangles suspended in the open, if struck with a sledge or large hammer, give a large volume of sound.

AUTOMATIC FIRE ALARM SYSTEMS

34. The prompt discovery of fire would generally bring about prompt extinguishment, and as it is not practical to have some one on duty in all parts of a property all of the time, there are bound to be many instances where fire gains serious headway before being discovered, unless some system of automatic notification is used.

35. The automatic fire alarm system and the alarm connection on an automatic sprinkler system are the automatic notification facilities available. The sprinkler has the tremendous advantage of an opportunity to control or extinguish the fire as well as ability to set an alarm in motion, and this reason is undoubtedly the principal one why the less expensive automatic alarm system has not made more rapid strides. In cases where possible water damage may be as serious as the loss from fire itself, or where an automatic fire alarm can summon the efficient aid of either a local or a municipal fire department, their use should be given more careful consideration. Experience with the original non-compensating types of thermostat systems has shown many apparatus and service weaknesses, and these have resulted in an attitude toward all types of automatic systems, both on the part of the public and the fire insurance interests, more unfriendly than the facts really warrant. The development in recent years of better equipment and the use of compensating types of thermostats is proving very effective and as time goes on the use of automatic fire alarms will undoubtedly be extended. Next to automatic sprinklers it is the most important fire protection device, as the prompt detection and automatic notification of fire prevents, in most cases, any serious loss. Also this prompt notification of the outbreak of fire is of great value in facilitating the escape of the occupants of the building.

36. Where automatic alarm systems are installed in the same property with automatic sprinklers, it is necessary that the automatic alarm system should operate first, giving an opportunity to extinguish the fire before the sprinkler heads open with the resulting damage from water. An approved automatic alarm system under constant test, backing up a sprinkler system, which is subject to certain interruptions of service, provides the acme of protection.

CLASSES OF AUTOMATIC ALARM SYSTEMS.

37. There are two general classes of automatic alarm systems: one class in which the detectors act at a predetermined temperature; the other class in which the detectors are "compensating" and act on a certain rise of temperature within a given time. The latter class is common in England and the Continent, while in this country the predetermined temperature class has been used exclusively until within the last few years.

THERMOSTATS.

38. The most common type of predetermined temperature systems use thermostats designed to open or close an electric circuit and operate registering apparatus or cause bells to be rung at designated points. The thermostat may be of a fixed temperature type or of a type capable of adjustment to operate at any one of several temperatures. Of these types of thermostats the former are chiefly of the solder type, and the latter generally uses a spring of two dissimilar metals which expand unequally. The detecting elements may be continuous or located at designated points in the ceiling.

39. There are several types of solder thermostats in use, most if not all of which use the same solder as automatic sprinklers with melting points of 160° F., 212° F., and 286° F. The 160° F. solder is used wherever the temperature does not exceed 125° F. The solder type of thermostat provides a fixed operation point, is reliable and simple in operation, and some designs of this type have already given good service.

40. For general use it would appear that the solder type of thermostat has many advantages over the adjustable type when used in connection with a simple closed circuit system. The adjustable thermostat with its moving parts is liable to mechanical difficulties and likewise subject to misadjustments. The present types of this class have other objectionable features.

41. Thermostats are usually located on the ceiling 10 to 12 ft. apart, and all portions of the property should be thus protected. They should be grouped on circuits which are separated for each portion of the property, the circuits ending in some form of annunciator, to indicate the location of the fire. Only the highest grade of wiring materials run in conduit should be used and installation made with good workmanship. Failure to observe these requirements has caused a large part of the unsatisfactory operations of automatic thermostat systems. Closed circuit systems, where the wiring and parts are under constant test or electrical supervision, as required by the signal rules, are much more valuable and reliable than open circuit systems.

COMPENSATING SYSTEMS.

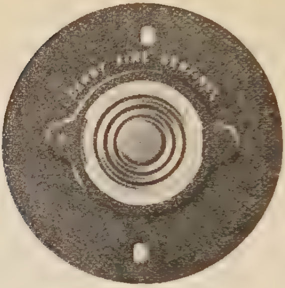
42. The chief advantage of the "compensating" class of automatic alarm system is that the alarm is sounded whenever the temperature starts to change at a certain rate, without waiting for the development of an amount of heat required to operate a predetermined temperature device or a sprinkler head located at definite points in the ceiling. A gradual rise of temperature, such as that caused by natural atmospheric changes or a heating system, should not give a signal. Systems not properly maintained may give false alarms, and if not properly installed will develop maintenance difficulties. The character of maintenance service given an Automatic Alarm System will largely determine its success; therefore, the experience and reliability of the organization responsible for such service should be given careful consideration. It is evident that a system in which it is possible by mechanical tests to create fire condition throughout all the detecting elements, backed up with a responsible organization to carry out these tests at frequent intervals, will give the most effective protection.

APPROVED SYSTEMS.

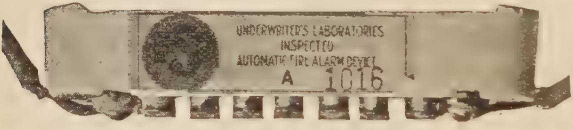
43. **The Aero System** (compensating) originally developed in England uses a pneumatic detector in the form of a continuous small copper tube reaching all spaces to be protected. Loops of tubing, not exceeding 1,000 feet in length terminating in two diaphragms, either or both of which may act in case of fire, make up the detecting units of this system. An adjustable relief valve permitting the escapement of a predetermined amount of air, furnishes the compensating feature, and permits of adjustment for a wide range of normal heat changes. Under ordinary conditions system operates on a temperature rise of 10 degrees F. per minute. The closure of any diaphragm starts the operation of the local alarm bells and trips a transmitter sending the code number of the building to the central station or fire headquarters. The transmitter and all electrical parts of the system are under constant test and any interference with the service will automatically send a trouble signal. As the operating element is the air in the tubing the system will function repeatedly without the replacing of any of these parts. In several cities this system is operated under full central station supervision. See Fig. 143.

44. The **Derby Fire Sentinel** (fixed temperature) is an approved fixed temperature device, set to operate at 165°, 212°, 286°, or 360°, as desired. It is simple in construction, with no moving parts, requires no adjustment, and is affected little if at all by atmospheric or minor corrosive influences. This device is reliable in its operating and not subject to false alarms. The Sentinels are wired on a closed circuit system, under constant electrical supervision, so that in the event of any derangement, such as a broken wire, current supply cut off, or tampering, immediate notification of trouble is given to those in authority. See Fig. 142.

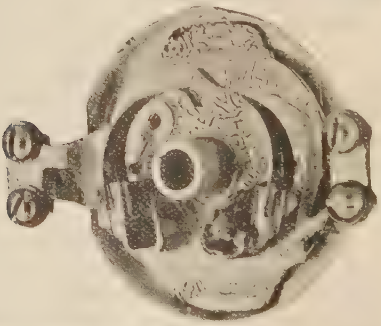
45. The **Fire Detecting Wire System** (fixed temperature) employes a continuous length thermostatic wire fusing at 180° F.



Case A. Derby Fire Sentinel, mounted on cover of conduit outlet box.

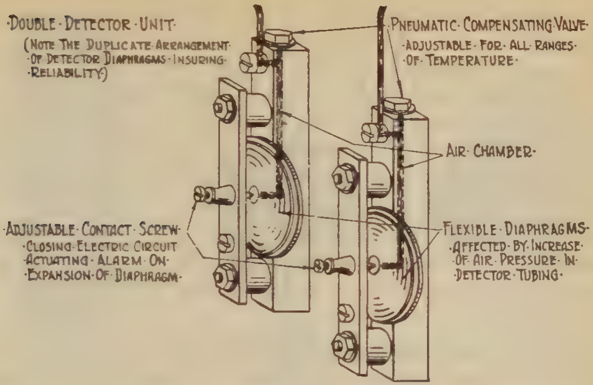


Case B. Reichel Thermopile Detector No. 3. Carries 7 pair of bismuth and antimony studs, which generate current upon rise in temperature.

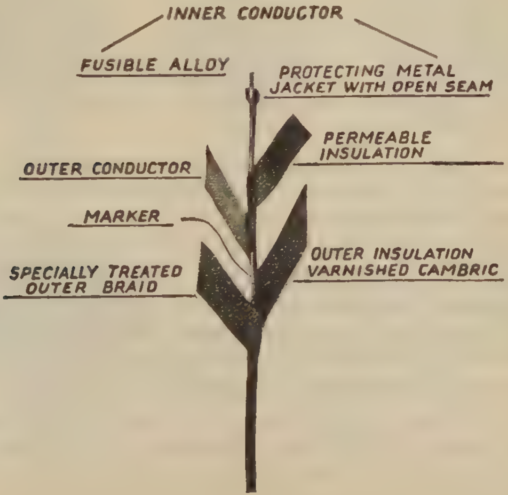


Case C. Watkins Two-Coil Thermostat with cap removed. Expansion of thermostatic strips makes scraping contact on silver surfaces.

FIG. 142. APPROVED AUTOMATIC FIRE ALARMS


·DOUBLE·DETECTOR·UNIT·
(NOTE THE DUPLICATE ARRANGEMENT ·OF DETECTOR DIAPHRAGMS·INSURING· ·RELIABILITY·)
·PNEUMATIC·COMPENSATING·VALVE·
·ADJUSTABLE·FOR·ALL·RANGES· ·OF·TEMPERATURE·
·AIR·CHAMBER·
·ADJUSTABLE·CONTACT·SCREW·
·CLOSING·ELECTRIC CIRCUIT ·ACTUATING·ALARM·ON· ·EXPANSION·OF·DIAPHRAGM·
·FLEXIBLE·DIAPHRAGMS·
·AFFECTED·BY·INCREASE· ·OF·AIR·PRESSURE·IN· ·DETECTOR·TUBING·

Case D. Acro Alarm Double Detector Unit connected to both ends of loop of copper tubing.


INNER CONDUCTOR
FUSIBLE ALLOY
PROTECTING METAL JACKET WITH OPEN SEAM
PERMEABLE INSULATION
OUTER CONDUCTOR
MARKER
OUTER INSULATION VARNISHED CAMBRIC
SPECIALLY TREATED OUTER BRAID

Case E. Fire Detecting Thermostatic Wire.

FIG. 143. APPROVED AUTOMATIC FIRE ALARMS.

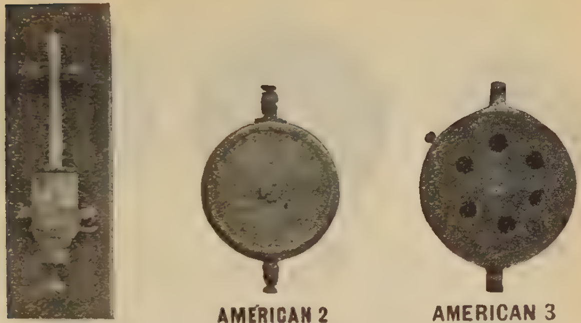
under flash fire conditions and at 160° F. under slow heat. The thermostatic wire is also approved for 212°, 286°, and 350°.

The system operates on a completely closed circuit including the thermostatic wire which is under supervision. The wire is installed flat on the ceiling on 10 ft. spacing in lengths of 1,000 ft. or less per section. The system operates on 20 volts using either Primary or Storage batteries and may be either Code or Non-Code. If Non-Code, the alarm is sounded on vibrating gongs and indication given by means of an indicator drop on a centrally located panel. If Code, the alarm is sounded on a series of single stroke gongs giving the code number of the section affected. See Fig. 143.

46. Fire Detection Service (Reichel System) (compensating) uses as heat detectors, thermopiles of special design, spaced about 20 feet apart, connected in series with a galvanometer in a closed electrical circuit. Any sudden rise of temperature (at the rate of 18 to 20 degrees F. per minute) generates sufficient electrical current to actuate the galvanometer, causing a transmitter to send in a separate alarm of trouble. The thermopile detectors are grouped on circuits covering specified areas, with galvanometers grouped in one control unit which acts as an annunciator to give closer location of the fire. See Fig. 142.

47. The rules and requirements of the National Board of Fire Underwriters for the construction, installation, and use of signaling systems include automatic fire alarm systems and thermostats, and should be consulted by any one before installing this class of apparatus. The rules provide for only closed circuit or supervised systems operated through central stations, except where connected directly to municipal fire alarm systems with operators constantly on duty at the fire alarm headquarters to act on signals in the same manner as attendants at a central station.

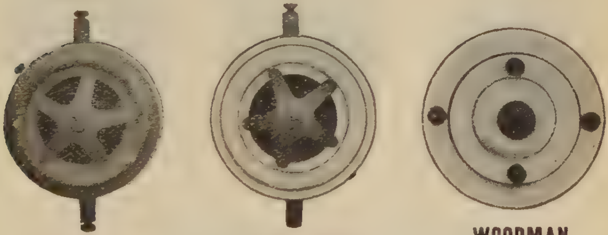
48. Fires from signaling systems, owing to crosses with high tension circuits or to lightning, are rather common, and it is particularly important that installations of signaling circuits, or of other circuits after signal ones are in place, be made with this danger in mind. Special protectors with spark gaps and ground wires or fuses are usually advisable. Wherever very high tension



AMERICAN 1
MERCURY TYPE
1884

AMERICAN 2
BRASS CASE
1885

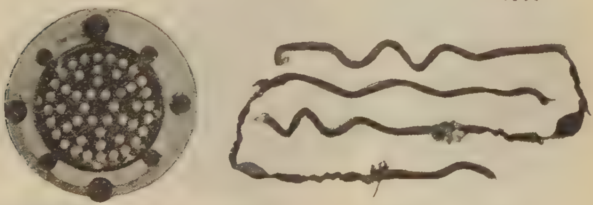
AMERICAN 3
PERFORATED FIBER CASE
1886



AMERICAN 4
OPEN FIBER CASE
1890

AMERICAN 5
PORCELAIN CASE
1898

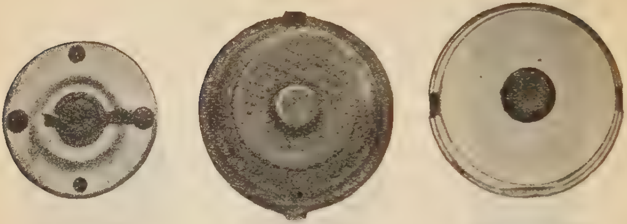
WOODMAN
OR
NATIONAL
1900



BRAZELTON
1892

BUELL
SOLDERED WIRE
About 1876

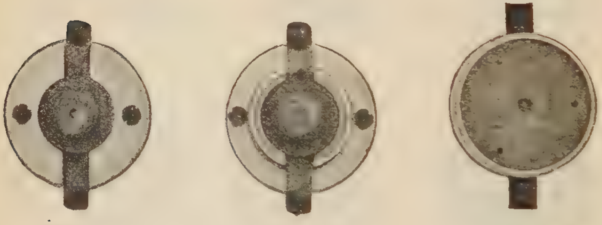
Fig. 144 Thermostats.



COPENHAGEN
1889

HEAT ALARM
WOOD BASE
1892

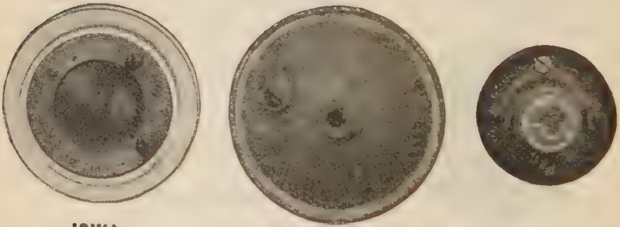
HEAT ALARM
PORCELAIN BASE
1892



HERSEY 1
1898

HERSEY 2
1899

HILL
1884

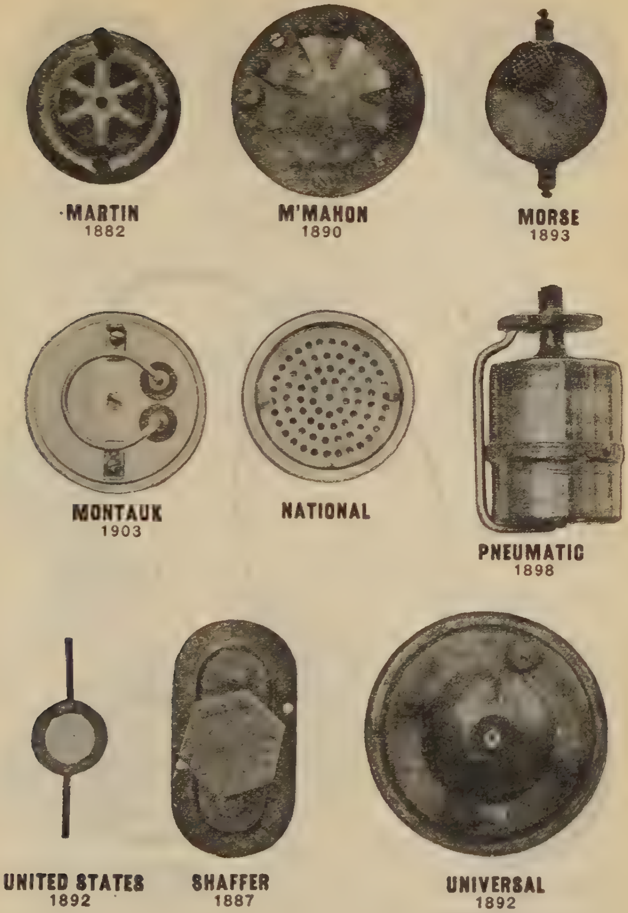


IOWA
1892

LUDLOW
1893

MACKEY
1887

Fig. 145. Thermostats.



MARTIN
1882

M'MAHON
1890

MORSE
1893

MONTAUK
1903

NATIONAL

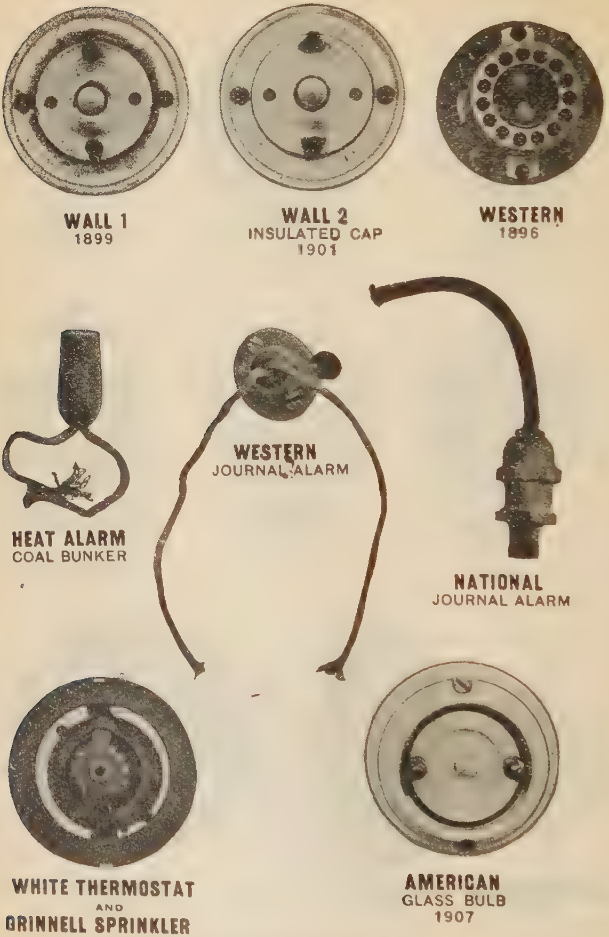
PNEUMATIC
1898

UNITED STATES
1892

SHAFFER
1887

UNIVERSAL
1892

FIG. 146. THERMOSTATS.



WALL 1
1899

WALL 2
INSULATED CAP
1901

WESTERN
1896

HEAT ALARM
COAL BUNKER

WESTERN
JOURNAL ALARM

NATIONAL
JOURNAL ALARM

WHITE THERMOSTAT
AND
GRINNELL SPRINKLER

AMERICAN
GLASS BULB
1907

Fig. 147. Thermostats.

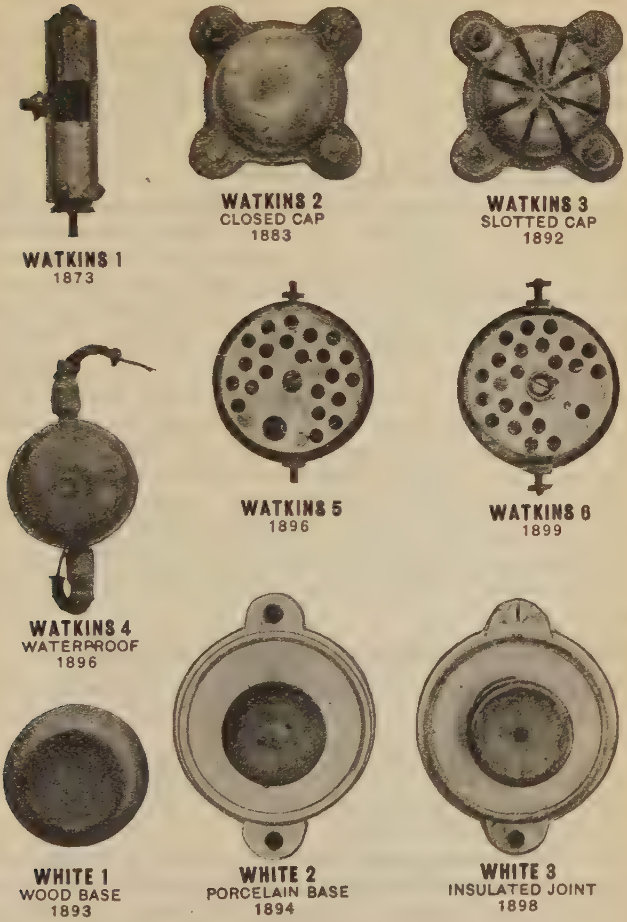


Fig. 148. Thermostats.

crosses are a possibility, such protectors should be of special design and located outside of important buildings.

49. Figs. 142 and 143 show approved compensating devices and thermostats. In Figs. 144 to 148 are illustrated most of the other devices which have in the years gone by had any appreciable popularity.

AUTOMATIC JOURNAL ALARMS.

50. The journal alarm is nothing more or less than a thermostat constructed and adapted for use on journals or on shafting. These alarms are generally set to operate at 160° F., the same as with the regular automatic alarm, and the solder type is more frequently used. It is evident that sensitiveness, i.e., quick action, is not a factor, and the construction is therefore different, it not being necessary to insulate the solder or operating parts. The journal alarm is screwed into or fastened directly to the journal or bearing, so that as the bearing gets hot the thermostat assumes the same temperature until it finally operates and rings the alarm. Journal alarms are used more particularly in grain elevators or similar plants, where shafting is liable to get out of line and cause trouble. It is valuable other than from a fire standpoint, in that heated bearings cause loss of power, and it is economical to have shafting properly adjusted, cleaned, and oiled.

WATCHMAN'S TIME-RECORDING APPARATUS.

51. The methods by which the actions of watchmen are checked up include:

a—Central station supervisory systems.
b—Reporting via telephone to point in plant.
c—Local stationary systems.
d—Portable watch clocks.

52. The **central station system**, if properly administered, has the advantage of making it possible promptly to follow up any failure of the watchman to register his rounds. On the other hand, it is an expensive system to maintain and is available only in the larger cities.

53. Having watchman **report via telephone** to a central point in the plant is entirely practical in connection with large plants having a number of watchmen, the system being quite similar to that used by police officers patroling beats. Special apparatus combining watchmen or police supervision with local fire alarm service can now be secured.

54. The **stationary system,** generally of the magneto type, except for certain types of property is not as popular as the watch clock because it costs considerably more money and has no particular advantages over the portable clock. Stationary system upkeep is likely to be more troublesome, especially where corrosive influences attack wires and magneto sending stations.

55. The approved **portable watch clock** is far more commonly used than the other three systems put together. Approved portable watch clocks are quite safe against tampering, and their simplicity, cheapness, and general reliability has brought them into common use.

56. Certain watch clocks are designed to be particularly tight against dust, which is an important factor in certain kinds of plants.

WATCHMAN SERVICE

57. Closely allied to the question of the watchman's time-recording apparatus is the subject of watchman service. Commonly enforced insurance requirements regarding watchman service are:

a—To be maintained nights, Sundays, and holidays, and at all other times when plant is not in operation. First round to be begun immediately after operations at plant are suspended and continued until the arrival of such persons or person as shall relieve him of his responsibility. Rounds to be made at least every hour nights and every two hours during the daytimes.

b—Watchman to record on approved central station system; or

c—Watchman to record on approved watch or clock. Dials to be checked and changed daily unless clock is arranged to register distinctly for more than a 12-hour period in which case dials may remain on for not over two days. Dials to be dated and kept on file for inspection.

d—There shall be a sufficient number of stations to insure watchman visiting all portions of risk. Same to be located under the supervision of the underwriters having jurisdiction.

e—Wiring and all other matters pertaining to systems or system to be installed according to the rules of the National Board.

f—Watchman to be employed for watching the plant only.

58. The average night watchman performs a double function, namely, protection of property against theft and protection against fire. While it is debatable in many properties whether a watchman may not be more of a fire menace than a fire prevention agency, it is generally true that the combination duties which devolve upon him make it wise in all cases to have a property watched.

59. Occasionally, where excellent outside protection by the police is available, the watchman is dispensed with, and where the property has sprinkler protection a sprinkler alarm system is connected to central station or to nearby engine house, or in any event to gongs on the outside of the building which will promptly notify passersby in event of fire breaking out inside the building.

60. It is a well-established fact that a very considerable proportion of the fires in plants under watchman service are discovered by outsiders, and this of necessity is so because the watchman passing through the property at hourly intervals is not likely to be close to the seat of fire outbreak where the property is of some size.

61. When watchmen discover fire they not infrequently fail to do the correct thing. They are prone to try to fight the fire rather than promptly to turn in an alarm. Occasionally watchmen get excited and shut off indicator posts controlling sprinklers, and that is the very last thing which should be done.

62. Watchmen have caused many fires through smoking, by the careless use of matches, and by the breaking of lanterns or the carrying of lanterns into dangerous locations.

63. Where the watchman has a property of some size in his care, he should devote his energy to watching the plant and not be obliged to sweep up, attend fires, and do similar work.

64. Watchmen should be fully instructed as to what to do in case of an emergency, and should, among other things, be able to do the following:

a—Promptly locate fire alarm boxes and transmit alarms.
b—Understand the use of all hand extinguishing apparatus.
c—Know the use of, and the location of, various sprinkler valves, primarily so that they may be shut in event of a sprinkler failure and after sprinklers have definitely put out any fire that may have broken out.
d—Operate fire pump, where it may be his duty to start this.

65. To have capacity to acquire this knowledge and to handle himself properly in the time of an emergency obviously requires that the man in charge of the property should not be, as so often is the case, aged, infirm, non-intelligent, and otherwise inefficient. The practice of using for watchmen men who are unfit for any other kind of work is certainly not to be commended.

66. There are portions of plants where it is probably unwise or undesirable for the watchman to go, such, for instance, as closed warehouses or portions of rooms where volatile liquids are stored.

67. It is obvious that even with the best of watchman service the automatic notification which is given by sprinkler alarms or by automatic fire alarm systems very materially increases the safety of the property. See tables on pages 744 to 746.

68. Watch service has been carried to a fine degree by a number of big corporations. One important merchandising house, for example, has something like 60 watchmen working 30 in each of two 7-hour shifts, and their routes so laid out that every part of the property is visited every 15 minutes.

69. There has been considerable controversy over the various methods employed for watching the watchmen. Because of the weakness in watchman service as a whole, it is probable that too great importance has been given to methods employed for keeping track of watchmen, and that any method which gives fairly reliable service should ordinarily be acceptable. See Watchman's Time Recording Apparatus.

RADIO SIGNALING APPARATUS

70. The astonishingly rapid introduction of radio systems, and especially amateur receiving stations, caused the National Board to issue tentative regulations in 1922. The National Electrical Code requirements are recommended in so far as they apply, especially to interior wiring; in addition the following safeguards are suggested:

a—Antennae to be clear of light and power wiring in event of a break in either the antennae or the circuit.

b—Provision of 2-way switch connected to an effective ground, and system grounded when not in use.

c—Provision, in addition, of an approved lightning arrestor of type operating at 500 volts or less.

INCENDIARISM.

71. Incendiarism, or arson, as it commonly called, is a widespread crime, although the number of really suspicious fires represents a small percentage of the total number occurring each year. The losses furthermore from such fires are a relatively small part of the total American fire loss. Arson committed by the owner of a building is virtually impossible to prevent, because he can put even a sprinkler system out of commission. Arson by a tenant is not infrequently frustrated or prevented from causing serious loss by sprinklers, automatic fire alarm systems, watchmen, or discovery by outsiders. Arson by outsiders is more easily guarded against, and a high degree of protection was developed during the late world war. Safeguards that are feasible and often desirable include:

a—Fencing property.
b—Locking buildings and protecting basement and first-story windows with permanent screens.
c—Police or watchman patrol.
d—Yard illumination.
e—Building wall illumination.
f—Sprinkler system valves locked open; not strapped or sealed with wire.
g—Plant fire alarm system.
h—Adequate fire apparatus.
i—Well-trained fire brigade.

72. It is desirable that any important property, particularly when not located in the congested district, and especially if not under automatic sprinkler protection, take into account at all times the possibility of incendiary fires.

CHAPTER 36

EGRESS FACILITIES AND DRILLS

1. Just as a given building can safely carry only a certain load, so a given building should be allowed to contain only such a number of persons as its construction, protection, height, character of occupancy, and exits warrant. This by no means is the accepted theory, but it is believed to be the coming one. Already some states base their limit of the number of occupants of a building upon the stairs or horizontal exits available, and recognize the value of sprinklers in reducing life jeopardy by making credits for them. There is no argument on the points that life is safer in an incombustible than in a combustible building, with sprinklers rather than without, with vertical openings protected rather than open, in a low rather than in a high structure, and in one in which the fire hazard of the goods stored or used is low rather than moderate or high. The N. F. P. A. is sponsor for the American Engineering Standards Committee on a Building Exit Code and the fundamentals on which this committee is basing its work bid fair gradually to become nationally accepted.

FUNDAMENTAL CONSIDERATIONS.

2. Except in the case of explosions or flash fires, where even the most liberal exit facilities cannot be expected to save a portion of the persons exposed, the safe basis for determining the suitability of exits is the time required to empty the building of its occupants. The allowable time is a matter of judgment. It may be as low as one minute under very dangerous conditions, and ten minutes in a reinforced concrete, sprinklered machine shop. Three minutes about represents the average.

3. The unit width of stair measure is placed at 18 in., permissible in existing buildings, and 22 in., required in new buildings, and the number of lines of persons that can pass down the stairs in a building simultaneously is therefore readily determined.

4. Tests have indicated that persons can pass down an ordinary flight of stairs at a rate of 45 per minute past a given point and on the level at 60 per minute, in both instances without undue haste.

5. Under certain conditions, it may be advisable that all the persons in the building should be able to find ample room in the stair enclosures without being called upon to move down more than one flight to get to a point of safety. The number of persons that can be held single file, standing on every other step, in a stair shaft having an intermediate landing between floors, will probably be about ten, and where the stairs are enclosed, as many as fifteen people can usually be accommodated in a single line.

6. If a horizontal exit to another fire section or to another building is available, and if it is certain that it cannot be locked against those seeking exit, the Building Exit Code Committee specifies that the number of persons who are accommodated on both sides of the wall may be increased, over the number that the stairs and stair enclosures will hold, 50% for one horizontal exit, 75% for two, and 100% for three or more. It is furthermore specified that when all persons on both sides of a horizontal exit dividing wall are transferred to the smaller side, there shall be sufficient gross floor space to allow not less than 10 sq. ft. per person.

7. The student of egress problems is referred to the N. F. P. A. Proceedings for further information.

SPRINKLERS AS LIFE SAVERS.

8. For many years, there has been a growing realization of the added security to life which comes from automatic sprinkler protection. While the life loss records in sprinklered buildings (or any other buildings for that matter) are incomplete, the men in constant touch with the sprinkler problem from the beginning of its development recall no case of a loss of life in a fire in a sprinklered building which approximated that in buildings such as the Ashe, Binghamton Clothing Company, High Street in Newark, Collinwood School, and the Iroquois Theater. The official reports of practically every life loss fire contain opinions that had sprinklers been installed the loss of life almost certainly would not have taken place. Available records of life lost in sprinklered buildings indicate that explosion and flash fires are responsible for almost the entire number.

9 The opinion of the N. F. P. A. on the value of sprinklers as life savers is: "It is today an almost unquestioned fact that the automatic sprinkler affords the largest degree of protection of life against fire in practically all cases where there is combustible construction or material, the rapid burning of which is liable to be a menace to the lives of the occupants of the building" Automatic Fire Alarm Systems also have distinct value from a safety to life standpoint.

10. In the following sections are taken up the essential facts regarding the various means of egress, and in the order of their general desirability.

HORIZONTAL EXITS.

11. Persons can move horizontally much more rapidly than down stairs, and where a property is divided by one or more fire walls or where buildings are connected by bridges, fire drills should be based on first getting the people out of the immediate danger zone and then moving them downward. The maximum results with the minimum organization can be secured in this way.

12. A false sense of security, however, has existed in some cases. because, although persons might be moved into another fire section, the failure or inability to close one door, or the presence of a single unprotected wall opening might permit fire or smoke to jeopardize the occupants of the presumably safe section. That is why, even where a horizontal exit exists, the number of persons in each section should bear some reasonable relation to the total stair capacity.

SMOKEPROOF TOWERS.

13. Figure 149 shows various forms of this means of egress, which in substance is a separate fire-resistive shaft entered only from the outside. It was first used in Pennsylvania in the late eighties, and has gradually been introduced in various sections of the country. The primary advantages are:

a—A cut off fire and smoke-proof stair shaft, safe as long as any person can live in the building.

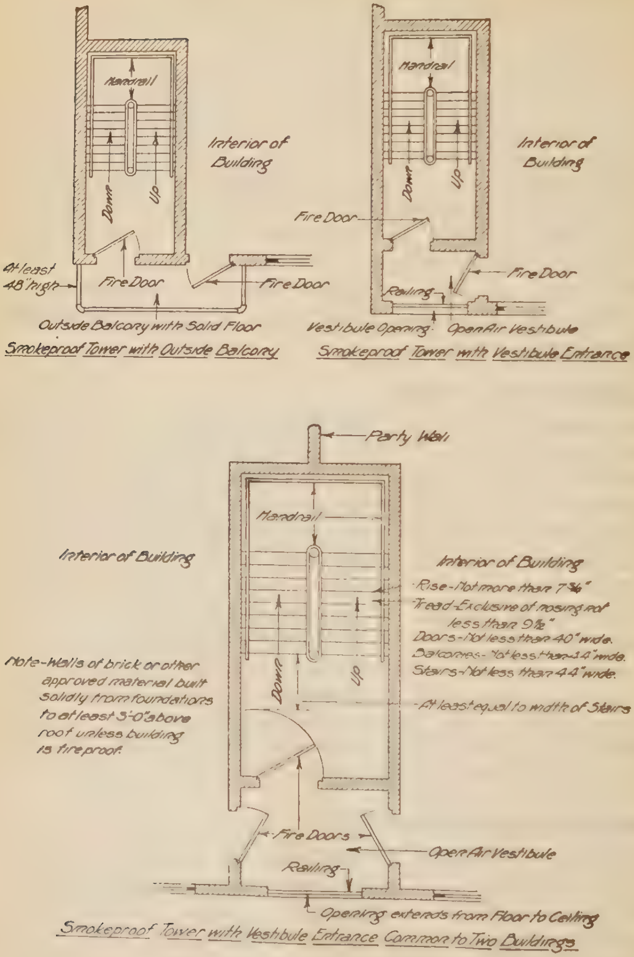

Handrail
Down
Up
Interior of Building
At least 48" high
Fire Door
Fire Door
Outside Balcony with Solid Floor
Smokeproof Tower with Outside Balcony
Handrail
Down
Up
Interior of Building
Fire Door
Fire Door
Railing
Vestibule Opening
Open Air Vestibule
Smokeproof Tower with Vestibule Entrance
Party Wall
Handrail
Interior of Building
Interior of Building
Rise - Not more than 7¾"
Tread - Exclusive of nosing not less than 9½"
Doors - Not less than 40" wide.
Balconies - Not less than 44" wide.
Stairs - Not less than 44" wide.
At least equal to width of Stairs
Note - Walls of brick or other approved material built solidly from foundations to at least 3'-0" above roof unless building is fireproof.
Down
Up
Fire Doors
Open Air Vestibule
Railing
Opening extends from Floor to Ceiling
Smokeproof Tower with Vestibule Entrance Common to Two Buildings

FIG. 149. SMOKE-PROOF TOWERS.

b—A means of floor to floor communication, normally used and not feared by employees, especially women, as is an outside fire escape.

c—A safe location for a standpipe for private or public department use, and a safe method for fire department reaching the floor on which fire has broken out. In high buildings this is of vital importance.

14. The essential features of the specifications are as follows:

15. Walls—To be brick, concrete, or tile, and to be self-supporting except in fire-resisting buildings. To have no openings except to outside of building.

16. Stairs and Landings—Preferably non-combustible. No winders to be installed. Stairs to be not less than 44 ins. wide. Landings to be at least as deep as the stairs are wide, except at the door landings, where depth shall be increased to give unobstructed use of stairs when door swings open. Rise shall not exceed 7¾ ins., and treads shall not be less than 9½ ins. wide, exclusive of nosings.

17. Rails.—Continuous where possible, to be provided on each side and also in the center, where widths require this.

18. Doors—Doors to swing into shaft, except at point of exit where they should swing outward.

19. Doors to be hinged upon the down side wall, so as to swing with the travel.

20. No lock whatsoever shall be placed upon tower doors.

21. Doors to vestibules or balconies may be locked by bolts on inside, so arranged as to be easily operated.

22. No padlocks requiring keys to be allowed.

23. Balconies and Vestibules—Floors to be non-combustible and to be solid. Rails to be not less than 4 ft. high. Width of platform to be at least 44 ins.

24. Illumination—A separate circuit from switchboard to supply each tower, and wires to be carried in conduit from switchboard to the tower.

25. Lights to be provided in each story, and preferably so arranged that all lights can be turned on from switches placed in tower near doors and in building near doors at entrance to balconies or vestibules. The sign "Fire Escape Lights" should be painted on the wall near the switches in the building.

FIREPROOF SHAFTS.

26. Stairs, when located in fireproof shafts directly connected to the building, may, owing to fire or smoke, become impassable to all persons above any floor on which a door is open. Nevertheless, this form of exit has proved a very satisfactory one, and has been the standard in the best types of factory buildings. Certain essential features include:

a—Doors should swing with the travel or slide across it.
b—Stairs should be broad, easy, and free from winders.
c—Continuous railings should be provided on both sides of stairs.
d—Ventilator of liberal area should be placed on roof to carry off smoke which may enter the shaft.
e—In many locations, stairs should be carried to roof.

ORDINARY INSIDE STAIRS.

27. A shaft entirely enclosing stairs, even if shaft is not fireproof, can be converted into a fair escape. Stair enclosures should take the form of a shaft, rather than to be individual for each flight of stairs. Persons should not be required to enter each story in going up or down stairs. In this connection, see treatment of vertical opening problem on page 201 and Fig. 29 on page 203. Figure 150 shows the device used to fasten down a trap door on its underside, which was partly responsible for the loss of 12 lives in the Diamond Candy Co. fire in Brooklyn in 1916.

ELEVATORS.

28. Elevator shafts produce powerful drafts and quickly become impassable to cars, unless effectively enclosed. Even if it is not planned to use elevators for getting persons out of a building, the shaft should be enclosed to retard the spread of fire and smoke. In high buildings, it is quite essential that, in addition to adequate stair capacity, plans should be made to use elevators to get at least a portion of the persons out of the building in event of fire. Features that warrant consideration include:

a—If elevators are driven by electric power, the current supply should be safeguarded against interruption at time of fire.

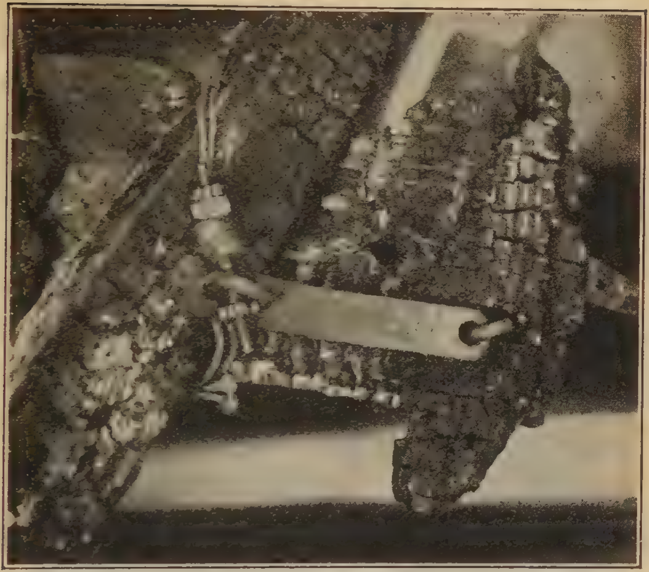


Fig. 150. Lock on Underside of Stair Trap Door.
(Diamond Candy Co. fire.)

b—Elevator operators should be drilled to carry persons from floors above the fire to the floor immediately below the fire, from which point they can walk down stairs at their leisure.

c—Provision should be made to carry private fire brigade and also the public fire department to the floor on which fire is located. For advisable types of doors to be used on elevator shafts, see Chapter 15.

OUTSIDE FIRE ESCAPES.

29. Practically every city prescribes fire escapes in some form for buildings over three stories in height, especially if occupied for manufacturing purposes or if used as places of public assembly. It is not an exaggeration to say that a very large percentage of the outside escapes today provided are exceedingly deficient, chiefly for the following reasons:

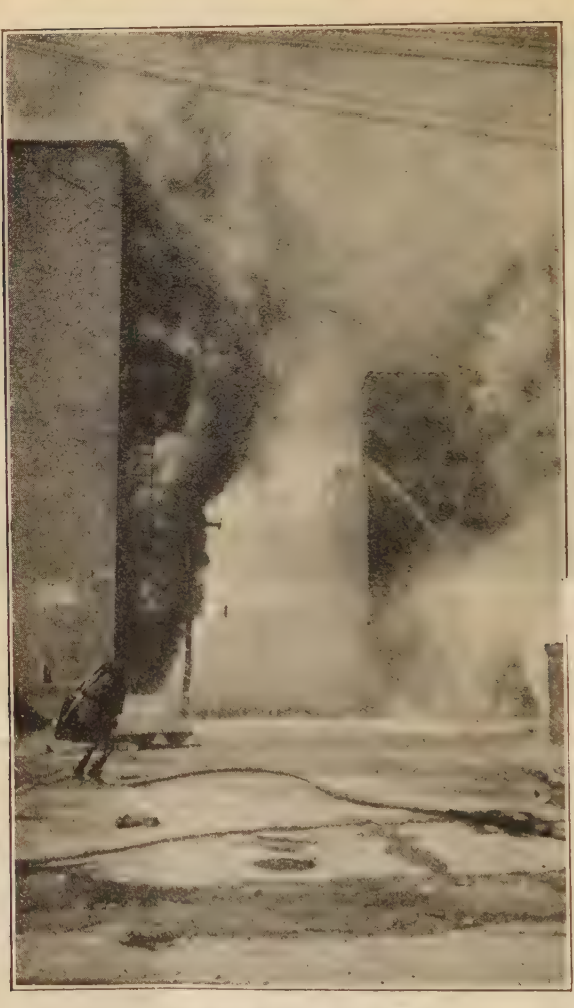
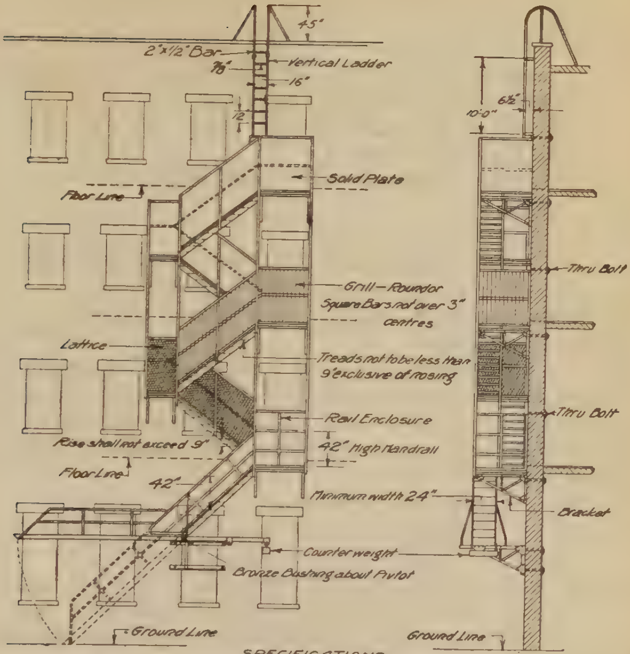


FIG. 151. UNPROTECTED FIRE ESCAPE, ON WHICH SEVERAL LIVES WERE LOST.
(Binghampton Clothing Co. Fire.)



SPECIFICATIONS

Height of Building—Not recommended on buildings over six stories in height

Location—Stairs should preferably be against blank wall, access from all openings to stairs being by horizontal balconies. Wall openings within 10' of such stairs to be protected by approved automatic fire doors on doorways and automatic or fixed fire windows on window openings

Doors—Shall have minimum width of 30" and minimum clear height of 78"

Balcony and Stair Enclosures—Shall be at least 50" between railings on superimposed form and at least 36" in straight run stairs.

Stairs—Minimum clear unobstructed width, shall be 24". The pitch of stationary and of swinging stair (when down) shall not exceed 45°

Fig. 152. Standard Outside Stairs.
(As Recommended by the N. F. P. A.)

a—Inaccessible to many portions of the buildings, except by going into halls that may be impassable owing to flames and smoke.

b—Unshielded against fire in lower stories. See Fig. 151 illustrating the unprotected fire escape on the Binghampton Clothing Co. building. The fire in lower stories cut off the use of the escape by those above and contributed to the loss of 35 lives.

c—Poor design, especially as regards steepness and lack of width.

d—Poor supports.

e—Complicated ladders and swinging stair arrangements to cover drop from second story to ground.

f—Poorly maintained, including ice and snow covering.

g—Used for storage.

30. For high buildings in which many persons congregate, the ordinary outside iron fire escape is deemed entirely unsuitable, giving a false sense of security. The Building Exits Code contains specifications for outside stairs (fire escapes). Essential features include:

a—Not permitted on new buildings.

b—Limited on existing buildings to certain classes, and to six stories in height, or 70 ft. from ground.

c—All wall openings must be protected with wired glass in metal frames or with fire doors, where near stairs if within 10 ft. above, 35 ft. below, or 15 ft. horizontally.

d—Solid platforms and solid treads required.

e—Factor of safety of 6.

f—Easy stairs, adequate handrails, and easy access.

g—Permanent stairs carried to ground or counterbalanced stair sections required.

31. Figure 152 illustrates one form outside stairs built in accordance with the N. F. P. A. specifications.

32. It is believed that these specifications will meet all state and city requirements, and they should be studied in every case where an installation of this kind is contemplated.

PORTABLE AND INDIVIDUAL ESCAPES.

33. These are particularly adapted to hotels, dormitories, and dwellings where it is not feasible to provide outside escapes which can be reached from all, or even from a majority, of the rooms without passing into halls.

34. The simplest form is the rope fastened securely and of sufficient length to reach the ground. The diameter to enable a good handhold being secured should be about 1 in. It requires experience and strength to lower one's self several stories. For women and children, ropes are valueless, unless used to lower the person after being tied around the body.

35. Rolled steel cable ladders are preferable to ropes, because the danger of falling is greatly reduced. However, it takes some skill to climb down a swinging ladder. Only substantial ladders, arranged to keep the rungs a reasonable distance from the building wall, are recommended.

36. The best escape is one which will lower a person or persons at a uniform and moderate rate of speed and without any action on the part of the occupant of the broad belt usually placed under the arms. Automatic speed regulation is necessary. Speed controlled by adjusting friction by means of a rope sliding through the hands is objectionable because not easily understood, and also because bad falls may be the result of over-speed.

37. It is generally good policy to arrange escapes so that they can be moved to any one of several windows, so as to permit escape even if fire is breaking out of some windows below.

EXIT DRILLS.

38. The 1912 rules of the N. F. P. A., entitled "Suggestions for the Organization and Execution of Exit Drills" represent the best thoughts advanced to date, and contain sufficient data to enable the establishment of drills at plants of almost every conceivable character.

39. The rules contain a general section applicable to most properties, and special portions devoted to conditions in schools, department stores, and theaters. These rules should be studied whenever it is desired to install exit drills.

CHAPTER 37

SELF-INSPECTION

1. Fortunately, the day has passed when the managers of a considerable proportion of even the more important industrial plants appeared to rely upon insurance inspection service for ascertaining their plant weaknesses of a fire prevention and fire protection character. Valuable as insurance inspection reports frequently are, they are generally made primarily from the standpoint of furnishing information to the underwriters at interest, sufficient time is not devoted to the work to permit it to be done in great detail, and the local conditions of necessity cannot be so well known to men who come to the properties at rare intervals.

2. Practically every well-managed property today is inspected periodically by men assigned to that work, primarily for the purpose of ascertaining:

a—What possibilities of fire outbreak can be eliminated.

b—Whether fire fighting equipment and apparatus is in serviceable condition.

c—If employees are trained to meet a fire emergency.

3. While large plants will occasionally have up to a score of fire inspectors, in addition to large fire fighting forces, no plant is too small to avail itself of the valuable protection afforded by good self-inspection service. The work may take only a part of the time of one man, and it may be rotated among a group of men as, for example, electricians called upon in rotation to make electrical inspections.

4. The essentials of a good self-inspection service are:

a—A keen desire on the part of the management to have this work done well.

b—Selection of competent men to do the work.

c—Instructions to guide inspectors.

d—Check list to recall items to the inspectors.

e—Report blanks carefully filled out.
f—Correction by management of defects developed.

INSPECTION FREQUENCY.

5. Probably no two authorities will agree as to the best inspection frequency, and the needs vary greatly in different plants. A modern rolling mill presents quite a different problem from a chemical plant handling inflammable liquids. The degree of care exercised by the men in charge of different departments is also a vital factor. Generally, when a plant has been put into fine condition less frequent inspection is in order. Good average practice is believed to be:

a—Inspections weekly for housekeeping conditions.
b—Inspections twice a month of fire fighting equipment.
c—Inspections monthly of electrical work.
d—Surprise drills of fire brigade at about monthly intervals.

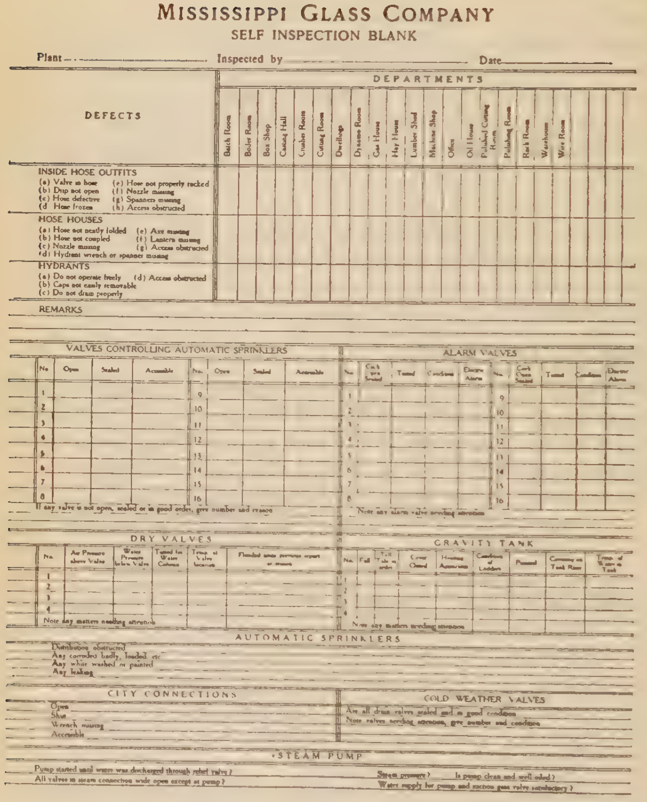
INSPECTION BLANK.

6. Figure 153 shows an excellent type of inspection blank, combining an instruction with a record blank. A particularly fine set of self-inspection forms used by a prominent corporation consists of three 8½ × 11-in. sheets covering the following:

a—Oils and grease, clean waste, oily waste, refuse and sweepings, combustible material, lockers and cupboards, steam pipes, fire doors, water pails and sand pails, chemical extinguishers.
b—Electrical circuit breakers, switches, fuses, wiring, pendent light cords, lamp guards and shades, fixtures, and rheostats and resistances.
c—Inside hose, outside hose houses, hydrants, sprinkler control valves, sprinkler alarm valves, sprinkler dry valves, gravity tanks, sprinkler heads, city connection, cold weather valves, steam pump.

7. Selections can be made from the inspection check list below and subjects added to meet the specific local conditions.

8. Ample space for comments is generally to be found on the back of these blanks. The spacing is, as a rule, one-sixth inch or one-third inch to fit standard typewriter spacing. The use of code numbers and letters for recording commonly found



MISSISSIPPI GLASS COMPANY

SELF INSPECTION BLANK

Plant ________ Inspected by ________ Date ________

DEFECTS	Batch Room	Boiler Room	Box Shop	Casting Hall	Crusher Room	Cutting Room	Dwellings	Dynamo Room	Gas House	Hay House	Lumber Shed	Machine Shop	Office	Oil House	Polished Cutting Room	Polishing Room	Rack Room	Warehouse	Wire Room			
INSIDE HOSE OUTFITS (a) Valve in hose (e) Hose not properly racked (b) Drip not open (f) Nozzle missing (c) Hose defective (g) Spanners missing (d Hose frozen (h) Access obstructed																						
HOSE HOUSES (a) Hose not neatly folded (e) Axe missing (b) Hose not coupled (f) Lantern missing (c) Nozzle missing (g) Access obstructed (d) Hydrant wrench or spanner missing																						
HYDRANTS (a) Do not operate freely (d) Access obstructed (b) Caps not easily removable (c) Do not drain properly																						

REMARKS

VALVES CONTROLLING AUTOMATIC SPRINKLERS

No.	Open	Sealed	Accessible	No.	Open	Sealed	Accessible
1				9			
2				10			
3				11			
4				12			
5				13			
6				14			
7				15			
8				16			

If any valve is not open, sealed or in good order, give number and reason

ALARM VALVES

No.	Cock Open Sealed	Tested	Condition	Electric Alarm	No.	Cock Open Sealed	Tested	Condition	Electric Alarm
1					9				
2					10				
3					11				
4					12				
5					13				
6					14				
7					15				
8					16				

Note any alarm valve needing attention

DRY VALVES

No.	Air Pressure above Valve	Water Pressure below Valve	Tested for Water Column	Temp. at Valve location	Flooded since previous report or reason
1					
2					
3					
4					

Note any matters needing attention

GRAVITY TANK

No.	Full	Tell Tale in order	Cover Closed	Heating Apparatus	Condition of Ladders	Painted	Covering on Tank Riser	Temp. of Water in Tank
1								
2								
3								
4								

Note any matters needing attention

AUTOMATIC SPRINKLERS

Distribution obstructed
Any corroded badly, loaded, etc
Any white washed or painted
Any leaking

CITY CONNECTIONS

Open
Shut
Wrench missing
Accessible

COLD WEATHER VALVES

Are all drain valves sealed and in good condition
Note valves needing attention, give number and condition

STEAM PUMP

Pump started until water was discharged through relief valve?
All valves in steam connection wide open except at pump?
Steam pressure? Is pump clean and well oiled?
Water supply for pump and suction gate valve satisfactory?

FIG. 153. SELF INSPECTION BLANK.
(Courtesy Mississippi Glass Co.)

defects greatly simplifies the making of entries. "10–C" may mean "danger of gas flames coming in contact with combustible material."

9. It is absolutely essential, if the truth about plant conditions is to be known, to require inspectors to enter those defects which are remedied as soon as found, together with a statement to that effect. The common practice of omitting any reference to deficiencies corrected very seriously weakens the ordinary inspection service.

SELF-INSPECTION CHECK LIST.

10. For the convenience of readers who desire to arrange self inspection blanks or to issue instructions upon this character of work, the following list of subjects and specific items under each is herewith submitted:

CAUSES OF FIRE.

ELECTRICAL EQUIPMENT.

1. CIRCUIT BREAKERS—(a) Not enclosed where danger; (b) Cabinet not lined; (c) Cabinet not locked—key in cabinet; (d) Breaker defective; (e) Blocked; (f) Set too high; (g) Cabinet door not closed.

2. SWITCHES—(a) Not operating properly; (b) Loose connections; (c) Not indicating; (d) Defective; (e) Not rigidly supported; (f) Not open by gravity; (g) Blades exposed short circuit.

3. FUSES—(a) Link or mica capped fuses not enclosed; (b) Bridged with wire; (c) No extra fuses on hand; (d) Circuit fused too high; (e) Enclosure defective; (f) Door not closed.

4. WIRING—(a) Defective insulation; (b) Not properly supported; (c) Temporary wiring; (d) Conduit outlets not bushed; (e) Grounds; (f) Circuits overloaded; (g) Connections not soldered and taped; (h) Solid wires for portable use liable to mechanical injury; (i) Conduit not grounded.

5. PENDANT LIGHTS AND EXTENSION CORDS—(a) Defective insulation; (b) Improperly supported; (c) Extension cords not reinforced; (d) Tied aside; (e) Adjusters needed; (f) In contact with sprinkler, water, or gas piping.

6. LAMP GUARDS AND SHADES—(a) Defective; (b) Shades combustible: (c) Guards not provided where liability of contact with combustible materials; (d) Vapor-proof globes missing.

7. FIXTURES—(a) Loose connections; (b) Do not operate freely; (c) Otherwise defective; (d) Arc globes missing or defective.

8. RHEOSTATS, MOTORS, AND RESISTANCES—(a) Rheostats not enclosed where inflammable dust or vapors; (b) Blocked in running position; (c) Do not release properly; (d) Contacts defective; (e) Motors sparking; (f) Resistances near combustible material.

9. CURRENT ON NEEDLESSLY—(a) Main switch not open at night; (b) On floor control, branch circuits or extension cords.

OTHER FIRE CAUSES.

10. GAS—(a) Iron pipe not used where possible; (b) Hose defective; (c) Danger of flame contact with combustible material. (d) Guards missing.

11. HEAT HAZARDS—(a) Ashes not kept in metal barrels; (b) Ashes not emptied daily, (c) Ashes mixed with combustible material; (d) Steam pipes against woodwork; (e) Combustible material against steam pipes; (f) Stoves or furnaces not safely installed.

12. REFUSE AND SWEEPINGS—(a) Not in metal barrels; (b) Barrels not emptied daily; (c) Barrels without covers; (d) Barrels defective.

13. WASTE—(a) Main supply of clean waste not kept in storage bin and local supplies in cans; (b) Oily waste not kept picked up and in approved cans; (c) Cans and covers not in good condition; (d) Oily waste not emptied at end of working day.

14. COMBUSTIBLE MATERIAL—(a) Storage not in bins or vaults; (b) Needless material in any portion of building.

15. OILS AND PAINTS—(a) Main supply not in oil house; (b) Daily supply not returned to oil house when not in use; (c) Unnecessary barrels opened; (d) Hangers and bearings not free from grease; (e) Drip pans needed; (f) Sawdust or shavings used to catch drippings.

16. GASOLENE AND OTHER INFLAMMABLE LIQUIDS—(a) Any storage except in oil house; (b) Torches not filled in oil house; (c) Torches or other daily supply not returned to oil house when not in use; (d) Empty containers allowed to accumulate.

17. MATCHES AND SMOKING—(a) Matches used by unauthorized persons; (b) Other than safety matches used; (c) Any tobacco smoking except in permitted sections; (d) Pipes placed in coat pockets.

18. LOCKERS AND CUPBOARDS—(a) Any not of metal; (b) Not clean; (c) Clothes not hung up; (d) Interiors not visible; (e) Tops not open to sprinklers; (f) Matches, oil, torches, or waste kept inside.

SPREAD OF FIRE.

19. FIRE DOORS—(a) Not operate freely; (b) Hanger bearings not greased; (c) Not automatic; (d) Link not exposed; (e) Not clear of obstructions; (f) Tin covering defective; (g) Hardware not complete; (h) Supporting bolts loose; (i) Not kept closed when not in use; (j) Not painted.

20. SHUTTERS—(a) Not operate freely; (b) Not clear of obstructions; (c) Tin covering defective; (d) Hardware not complete; (e) Supporting bolts loose; (f) Not closed at night or when buildings are not in use; (g) Not painted.

21. WIRED GLASS WINDOWS—(a) Not operate freely; (b) Automatic device, if any, not in order; (c) Hardware not complete; (d) Not shut and locked when not in use.

22. SKYLIGHTS—(a) Combustible construction; (b) Glazing not complete; (c) Wired glass, or other glass not protected with screens; (d) No special fine mesh screen where used for ventilating.

23. PLASTERING OR OTHER FINISH—(a) Any defective; (b) Needless combustible finish.

24. WHITEWASH—(a) Woodwork not whitewashed; (b) Whitewash not used to improve light.

EXTINGUISHMENT OF FIRE.

25. PUMPS—Use ten columns: (a) Number of pump; (b) Started up; (c) Date of last test with hose; (d) Minimum steam pressure since last inspection; (e) Steam pressure; (f) Steam valves wide open except throttle at pump; (g) Supply of oil; (h) Clean and well cared for; (i) Automatic regulator in order and valves open; (j) Relief valve set at.

26. FIRE DEPARTMENT CONNECTIONS—(a) Caps in order; (b) Frozen; (c) Access obstructed.

27. GRAVITY TANKS—Use ten columns: (a) Number of tank; (b) Whether full; (c) Tell-tale tested; (d) Cover closed; (e) Heated; (f)

Overflow; (g) Condition of ladders; (h) Tank requires painting; (i) Hoops in good condition; (j) Tank riser boxed completely.

28. PRESSURE TANKS—Use six columns: (a) Number of tank; (b) Water level; (c) Air pressure; (d) Are water gauge valves closed; (e) Temperature of rooms; (f) Remarks.

29. HYDRANTS—(a) Do not operate freely; (b) Caps not easily removable; (c) Do not drain properly; (d) Hydrants frozen; (e) Access obstructed; (f) Not provided with hose valves.

30. HOSE HOUSES—(a) Hose not neatly folded; (b) Hose not coupled up; (c) Water in hose; (d) Hose frozen; (e) Nozzle missing; (f) Wrenches or spanners missing; (g) Lantern missing; (h) Axe missing; (i) Access obstructed; (j) Not properly painted; (k) Roof defective.

31. INSIDE HOSE OUTFITS—(a) Water in hose; (b) Drip not open; (c) Hose defective; (d) Hose frozen; (e) Hose not properly racked; (f) Nozzle missing; (g) Nozzle not connected; (h) Spanners missing; (i) Access prevented by obstructions.

32. CHEMICAL EXTINGUISHERS—(a) Missing; (b) Not full; (c) Frozen; (d) Acid bottle not in place or improperly filled; (e) Caps not easily removable; (f) Gaskets missing or defective; (g) Tags not showing date of last charging; (h) Copper corroded; (i) Hose defective; (j) Nozzles defective or clogged; (k) Access prevented by obstructions; (l) Not prominent.

33. CHEMICAL ENGINES—Same as chemical extinguishers.

34. WATER PAILS AND CASKS—(a) Missing; (b) Not full; (c) Frozen; (d) Defective; (e) Access obstructed; (f) Not prominent.

35. SAND PAILS—(a) Missing; (b) Not full; (c) Sand wet; (d) Defective; (e) Scoop missing; (f) Access obstructed; (g) Not prominent.

36. SPRINKLER HEADS—Cover the following topics: (a) Distribution obstructed; (b) Corroded; (c) Whitewashed or painted; (d) Bent or leaking; (e) Deflectors missing; (f) Benches and stock clear of walls to allow water distribution.

37. SPRINKLER PIPING—(a) Not properly supported; (b) Need painting; (c) Improperly used as supports for material.

38. GATE VALVES—Fill out sheet having five columns: (a) Give number of each sprinkler controlling valve in supply pipe; (b) State whether valve is open or shut, (Cold weather); (c) Whether strapped or otherwise fastened; (d) If not strapped, the reason; (e) Accessible.

39. DRIP VALVES—(a) Tested; (b) Left shut; (c) Secured with strap or seal.

40. ALARM VALVES—Use six columns: (a) Number of valve; (b) Alarm cocks open and secured; (c) Note whether tested, and if with water flow; (d) Pressure above valve; (e) Pressure below valve.

41. DRY VALVES—Use six columns: (a) Give number of valve; (b) Air pressure above valve; (c) Water pressure below valve; (d) Tested for water column; (e) Temperature at valve location; (f) Flooded since previous report and reason.

42. PUBLIC ALARM BOXES—(a) Not placed prominently; (b) No signs giving location of box and key.

43. PRIVATE FIRE ALARM SYSTEMS—(a) Not tested regularly; (b) Instructions not posted; (c) Access obstructed; (d) Numbers on boxes tested.

EGRESS.

44. FIRE ESCAPES—(a) Escapes not unobstructed; (b) Access not clear; (c) No signs giving direction; (d) No special illumination; (e) Painting necessary.

CHAPTER 38

PROTECTION OF RECORDS AGAINST FIRE

By H. P. WEAVER *

1. With increase in magnitude of business operations, records have multiplied in number and complexity. They have become an implement essential to operations and an alert management foresees the hardships, financial and otherwise, which follow their destruction. Insurance, though available, is seldom carried on records to an appreciable extent.

2. Stimulated by the demand for record safety, engineering knowledge of and practice in record protection have moved forward rapidly of late. Much of previously accepted practice is now dismissed by the informed.

3. For most situations, it is possible to devise proper and sound methods of record protection, giving due weight to importance of records, probable severity and duration of exposing fire, structural features, merits of various record protective devices, and the practical limitations of cost.

Only a balanced and mature consideration of all of these things can lead to a correct conclusion. Generally, no one of them alone can be taken as a determining factor.

4. Having arranged proper facilities for the protection of records, it is necessary to exercise constant watchfulness to see that these facilities are used consistently, and kept at the maximum of effectiveness.

GENERAL METHODS OF FIRE PROTECTION

5. Clearly, those things which contribute to general fire safety must contribute to record safety as well. Fire causes should be eliminated. Advantage should be taken of structural measures to limit the spread of fire beyond point of origin whether internal or external to the premises. Extinguishing facilities adequate and appropriate to the situation should be provided. Proper methods of supervision, fire detection, notification, etc., should be followed.

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* General Manager, Independence Bureau. Chairman, N. F. P. A. Committee on Record Protection.

6. As to all of these things recognized standards are available, are discussed in other chapters of this book, and further comment need not be made. There should, however, be no failure to recognize that records frequently are irreplaceable or have value far beyond ordinary building contents, and hence a much higher degree of protection is justified than for purely commercial and replaceable values.

SPECIAL METHODS OF RECORD PROTECTION

IN GENERAL.

7. Fundamentally, there are three methods of record protection:

a—Duplication. Copies may be kept at another point chosen for minimum possibility of simultaneous destruction.

b—Insulation. Records exposed by combustible surroundings may be placed in containers designed to prevent penetration of sufficient heat to the records to cause their destruction.

c—Segregation. Records may be separated from combustible environment, or combustible materials other than the records themselves may be entirely eliminated.

Most methods of record protection involve one or more of these principles.

DUPLICATION.

8. While duplication at another point not subject to the same fire is probably the most effective means of protection, it should be remembered that making and filing duplicates involves expense, that in some cases the replacement of lost records from duplicates may involve within itself considerable expense, and, furthermore, that a copy frequently does not have the same value for legal purposes as a signed original document. Photographic reproductions often are best.

9. The existence of a duplicate set at another point in the same building should not be regarded as satisfactory protection unless

one of the copies is adequately and dependably protected against fire.

10. Great care should be taken to see that duplication is complete, accurate, and orderly. Points such as these should not be overlooked in assuming that mere duplication is always adequate protection.

SAFE DEPOSIT VAULTS.

11. Safe deposit vaults of the better type have almost a perfect record for protection of their contents against fire. Where vaults are located below ground level, and where there is danger of flood or of accumulation of water at time of fire, the record is not so clear. It is probably true that the average safe deposit vault would not successfully exclude water if submerged for a considerable period.

DOCUMENT BUILDINGS.

12. For storage of important records in considerable volume, a detached and unexposed building may be built where ground space is available. This permits transfer of old records from working areas in offices, releasing space for active material.

Such a building should be strictly fire-resistive in construction, should have entirely non-combustible interior equipment, and should be properly arranged as to all hazards of lighting, heating, etc. Suitable extinguishing apparatus should be provided.

VAULTS.

13. The N. F. P. A. specifications cover the following three classes:

Class A—Vaults designed to afford the maximum degree of protection, and intended for use by banks, trust companies, and others having large values to protect.

Class B—Vaults usually erected in tiers, and designed to afford a large measure of protection to their contents, assuming even the total destruction of the building in which vaults are located.

Class C—Vaults carried on the framework of fire-resistive buildings, and designed to afford a large measure of protection to their contents, assuming the integrity of the supporting structure.

Reference should be made to these specifications for complete details, not only in connection with new construction, but as a standard against which to measure the adequacy of existing vaults.

14. These N. F. P. A. specifications are intended primarily to secure safety against fire and building collapse. For burglar protection, the use of heavy and expensive steel linings has been customary. In 1922, based on elaborate comparative tests of several different types of vault construction with specific reference to attack with explosives and cutting torches, the Federal Reserve Board has adopted as a standard a new form of wall, floor, and roof construction, consisting of packed layers of large mesh expanded metal, filled with a rich concrete. No steel linings are used. Safety, speed of construction, and economy are all claimed for this design. A number of such vaults are already completed, including the one in the Federal Reserve Bank in New York City, which is at present the largest bank vault in the world.

15. In general, the following principles as to vault construction should be observed:

a—Foundations should be built upon the ground, or vault may be carried on the building structure, where this is known to be adequately protected against collapse by fire.

b—Walls, floors, roofs, etc., should be of brick, concrete, or equivalent fire-resistive material and should be ruggedly built.

c—Doors should preferably be of the "filled" type and of good design. Where exposing combustible is very limited in amount, double steel plate doors supported in steel vestibule may be acceptable. In the latter case there should be an interlocking mechanism to make sure that both doors are closed as dead air space is important.

d—It is highly important that vault vestibule be securely grouted, top, bottom, and sides, into the wall opening. A vestibule merely set into wall opening with flanges on each side is distinctly objectionable.

e—Trucking plates in vestibules are undesirable, but if unavoidable should be arranged to be easily removed.

f—Entire interior equipment should be incombustible.

g—Wiring should be in conduit without pendent or extension cords, and should be supplied by a short cord, carried through doorway, and plugged into a live receptacle on the outside. So arranged, cord must be detached and power shut off before door can be closed.

h—Vault should be clean and free from any avoidable combustible storage.

i—Smoking and the use of matches in a vault are clearly undesirable.

j—Ventilation should be only through door. Walls, floors, and roofs should not be pierced. If ventilating openings other than doors are provided, they should have fire-resisting protection equal to the doors.

k—Telephones in vaults, or call bells outside operated by push button in vault, are sometimes advisable to guard against persons being locked in and suffocated.

16. As between vaults and safes, the following advantages and disadvantages may be noted:

a—A vault can be made adequately fire-resistive regardless of the construction of the building in which it is located.

b—It is possible to make vaults more massive and rugged than safes if necessary.

c—If supports are properly designed, vaults need not be subject to falls or structural collapse.

d—Vaults will usually be found to supply more cubic feet of storage capacity per dollar of cost than safes.

e—Vaults are inflexible as to location, while safes can be moved as may be needed.

f—Vaults usually contain more records in one group and subject to the dangers of a single oversight, such as neglecting to close doors, than is the case with safes.

g—Vaults frequently collect needless combustible materials, rubbish, and even hazardous materials, wiring may be improperly installed, smoking may be practiced, etc. Safes will be found to be free from many of these difficulties.

IRON SAFES.

17. By this designation reference is made to the old familiar type which has been in use for many years, and which has appeared in two classes, the one a fairly light-weight safe having neither good fire-resisting power nor ability to resist burglars, and the other a much more substantially built and heavy device, able to resist fires of some duration and moderate falls.

Vigorous commercial controversies have raged in this industry, in which reports of tests to which safes were exposed in actual fires have played a prominent part. While generalities are dangerous, it is believed that the following is true:

a—The ordinary form of safe affords but little protection against experienced burglars.

b—The fire-resisting powers of many safes, even of the heavier design, have been surprisingly poor. In the large conflagrations, the contents of the majority of the safes were lost.

c—Heavy safes are often a life menace in buildings, crash down at time of fire, are likely to break open, and are almost certain to fill with water if they fall into it.

As compared to more recent types that have been subjected to furnace tests, and bear Underwriters' Laboratories label of approval, it can only be said that the choice lies between a device of known qualifications, as indicated by the tests, and one which is uncertain.

LABELED RECORD SAFES.

18. By this term reference is made to the type of safe which bears label of approval of Underwriters' Laboratories. These safes are available in the following classes:

TEST REQUIREMENTS OF UNDERWRITERS' LABORATORIES FOR LABELED SAFES AND CABINETS

Classification.	Length of Test.	Maximum Temperature Reached F.	Impact Test.	Explosion Test.
Class A................	4 hrs.	2000	Yes	Yes
" B................	2 "	1850	"	"
" C................	1 "	1700	"	"
Light Weight..........	1 "	1700	"	"
Insulated Cabinet......	45 min.	1640	No	No

Safes must stand above tests before internal temperature reaches 300 degrees F.

The impact test involves a fall in the clear of 30 ft. after safe has been heated one hour (reaching 1,700 degrees F.), and reheating as before impact in the inverted position.

An explosion test is made to determine whether a sudden heating will cause an explosion in the walls or interior.

19. From a consideration of the above classes, it will be seen that types are available for varying conditions, and decision as to which one is suitable for any particular instance, is a matter of judgment involving the importance of the records to be protected, the building construction, probable severity and duration of exposing fire, presence or absence of automatic sprinklers, and other factors. If building is of type subject to collapse by fire, then height above ground at which safe is to be located must be considered.

20. Assuming equal heat-resistive ability, it is believed that there are certain advantages in the heavy angle iron frame employed by many of the manufacturers of labeled safes.

RECORD ROOMS.

21. For bulky collections of records not of the very first importance, storage in vaults or record safes often is impracticable. Such records may be segregated from the exposure due to combustible contents, particularly in a fire-resistive building, by placing them in steel files in a room separated from the remainder of the building by proper incombustible partitions, with protected window and door openings, and equipped with metal furniture throughout. Any wooden trim or wooden wearing floor should be eliminated from such an enclosure which should contain no combustible other than the records themselves.

This arrangement gives large storage space per unit of cost, permits of working within the enclosure conveniently, and allows the use of ordinary steel filing devices. However, it can only be expected to give a moderate degree of fire protection.

STEEL FILES.

22. Experience indicates that ordinary steel files do not provide any considerable protection against transmittal of heat and damage to records. However, their use reduces the amount of combustible material, and this fact is sufficient to justify them. Aside from fire protection, steel files are durable, satisfactory in operation, and have other advantages. However, a degree of fire-resistive ability which they do not possess should not be expected of them.

The use of wheeled metal carriages for card files, books, and other records, conveniently used at work places by day and stored in vaults at night, is an excellent practice.

WOODEN FILES.

23. By some observers, wooden files are believed to have more resistance to the passage of heat than steel files, but they readily ignite, and present the great disadvantage of adding to the combustible material. Naturally they do not afford material protection to their contents.

CONSISTENT USE OF PROTECTIVE EQUIPMENT.

24. Protective equipment, no matter how complete, is of little value unless it is consistently used, and unless there has been forethought concerning procedure in an emergency. The following suggestions apply:

a—In case of sudden day fire, records must be restored to their places of safety accurately, quickly, and without confusion or oversight. In some cases the best plan is to have the most important records carried out of the building. Record drills to train employes to meet emergencies are not uncommon.

b—Records belonging in vaults or safes should never be left out over night.

c—Desks should not be allowed to accumulate important materials properly belonging under protection.

d—Records normally safeguarded are often unprotected while temporarily in other hands. Important documents may be in the hands of attorneys at other offices. Original deeds may be at the recorders' offices. Valuable tracings and engineering department records may be out for temporary use by men in the field. Wherever possible, only copies should be given out.

GENERAL RECOMMENDATIONS

25. For records of primary importance and for large values, first-class vault construction is always advisable. To secure equal capacity in safes of high fire-resistive ability is very expensive, wasteful of floor space, and produces exceedingly heavy loading of floors.

For records of moderate importance and value, when the quantity is large a Class B or Class C vault is recommended, and for small quantities, the use of labeled record safes is the solution. Record safes are sometimes placed in vaults to protect valuables against exposure from the burning of other contents in the vault.

CHAPTER 39

CONFLAGRATION HAZARD AND PROTECTION

1. The danger of a wide spreading fire, commonly termed a conflagration, unquestionably exists in every city or town in the United States and in Canada. The conditions which made possible the losses in the following tabulation, and many lesser ones, exist today to a large extent in all our closely built up sections.

CONFLAGRATIONS IN THE UNITED STATES INVOLVING LOSSES IN EXCESS OF $5,000,000

Date	Location	Loss
1835	New York	$15,000,000
1861	Charleston, S. C.	10,000,000
1866	Portland, Me.	10,000,000
1871	Chicago	168,000,000
1872	Boston	75,000,000
1874	Chicago	5,000,000
1875	Virginia City, Nev.	7,500,000
1889	Seattle	5,000,000
1889	Spokane	6,000,000
1889	Boston	6,000,000
1889	Lynn, Mass.	5,000,000
1892	Milwaukee	6,000,000
1900	Hoboken, N. J.	5,500,000
1901	Jacksonville	11,000,000
1902	Paterson, N. J.	7,000,000
1904	Baltimore	50,000,000
1906	San Francisco	350,000,000
1908	Chelsea, Mass.	12,000,000
1908	Chisholm, Minn.	5,000,000
1910	Cedar Spur, Mont.	6,000,000
1911	Albany, N. Y.	5,500,000
1914	Salem, Mass.	15,000,000
1916	Paris, Texas	10,000,000
1917	Atlanta, Ga.	5,500,000
1922	Chicago	8,000,000
1922	Astoria, Oregon	10,000,000
1923	Berkeley, Cal.	10,000,000

2. While in years gone by, no competent warning of inherent dangers preceded conflagrations, in more recent years the excellent examinations of and reports on city fire dangers, made by the engineers of the National Board of Fire Underwriters, have not only clearly pointed out possibilities, but have in several cases proved to be true prophecies, as witness the disastrous fire in 1917 in that block in the downtown district of Pittsburgh which the Underwriters had classed as the worst in the entire city, and in San Francisco, where in 1905 they stated that conflagration probability was "alarmingly severe."

3. While high pressure water mains and exceptionally efficient fire departments are of service in lessening the number of fires which become dangerous, they are all quite powerless in checking an onrushing conflagration—a fact to which the public prefers to remain in blissful ignorance. Such a wide-spreading fire is never "gotten under control" or "put out by the fire department." It burns itself out, with the fire department and water supply, if extensive enough, performing a limited service on either flank or at the rear.

4. Whether or not the conflagration hazard of our cities can be eliminated is doubtful, but the best authorities agree that it can be greatly reduced, and this in a practical and not financially burdensome manner. Remedies, used preferably in combination with each other, include:

a—The gradual elimination of wooden shingles and other combustible roof coverings.

b—The removal from central sections of highly hazardous operations and of particularly dangerous structures.

c—The construction in high value districts of only fire-resistive buildings of the best class.

d—The general raising of the standard of construction of all buildings.

e—Employing blank walls against very serious exposures, and the extensive use of wired glass, metal frame window protection, or shutters, on all buildings including fire-resistive ones.

f—The liberal, in fact general, use of automatic sprinklers in high value districts.

g—Improved water supplies and fire department efficiency.

5. Wooden Shingles—See page 217 for general comments on the danger of this type of roof covering. Atlanta, Chelsea, Jacksonville, Paris, and Salem are examples of conflagrations spreading largely owing to wooden shingles. No fire department can hope to cope with dozens of simultaneous fires in widely scattered sections.

6. Conflagration Breeders, as are termed very poor structures and those in which especially dangerous enterprises are carried on, are easily detected and should not be tolerated in high value districts. The Chelsea fire started in a wooden blacking factory. The Baltimore fire began in a wholesale clothing house with a wide open light well running to the roof.

7. Superior Construction should be mandatory in high value districts, and generally the whole American construction standards, except those voluntarily followed by our most progressive organizations, should be raised. The Building Code of the National Board should be even more widely adopted and enforced than it is.

8. Blank Walls are the best conflagration barriers. Often such walls are found to be entirely practical, when the existence of severe exposure is pointed out. Wired glass, metal frame windows (see page 240) are the best general protection against exposure fire, especially if combined with shutters where the exposure is very severe. It has been stated, on good authority, that a city completely so protected and with an effective fire department would be conflagration proof.

9. Automatic Sprinklers, extended generally to the high value districts and to important and hazardous buildings elsewhere in the city, undoubtedly would give the largest measure of protection against conflagration and earn the largest returns in reduced insurance costs, as well as in safeguarding business against interruption by fire. The general introduction of sprinkler protection is particularly feasible in cities having sufficiently high water pressures to constitute adequate single sources of water supply for sprinklers in buildings of ordinary area and height. Single sources of supply for ordinary buildings are deemed sufficient. In this connection, it is interesting to note that the data available regarding the water supplies of 81 of the 100 largest cities in the United States are as follows:

15 under 40 lbs.
66 in excess of 40 lbs.
50 in excess of 50 lbs.
38 in excess of 60 lbs.

10. A considerable number of cities, including larger ones, have pressures of 100 lbs. and upwards.

11. It is to be noted that these pressures are the minimum at any time during the 24 hours in the downtown districts.

12. These figures indicate that, in a surprisingly large number of our cities, it is possible to undertake general sprinkler protection without incurring heavy water supply costs.

13. So far, no American city has undertaken a carefully planned, comprehensive campaign to reduce conflagration hazard to a minimum. Progressive industrial plants commonly do this to their decided advantage, and there is no reason why a similar course cannot be followed by a city. It will require a vigorous insistence on the following of agreed standards, a willingness of property owners to co-operate, and a period of years to bring about the desired results. It is to be hoped that such a policy will be followed extensively before an additional number of our big cities are offered up as sacrifices to our national inertia on the subject of fire waste.

14. Haverhill, Mass., has accomplished a notable feat in so far as municipal safety from fire is concerned, in that the large majority of all buildings in the congested district are sprinklered, advantage being taken for water supply purposes of a special 110-lbs. high pressure main system. Furthermore, there is a particularly liberal hydrant service on both the high and the low pressure systems.

CHAPTER 40

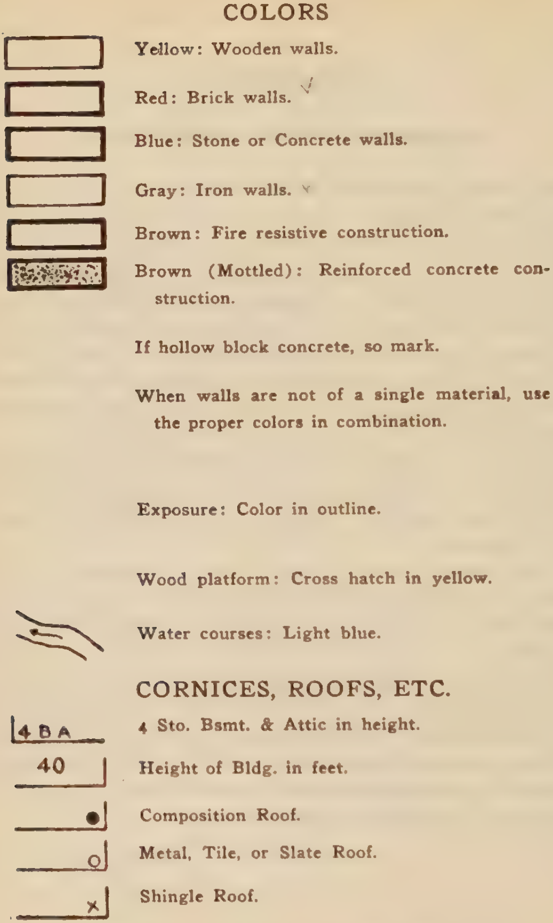
STANDARD PLAN NOTATIONS

1. For many years, there have been used in connection with insurance maps standard symbols to convey in concise and readily legible form information of value to underwriters and others regarding building construction, height, protection against exposure, fire protection, occupancy, special hazards, etc. An astonishingly large amount of valuable information can be conveyed in a manner hardly noticeable at first glance. The Underwriters' Uniformity Association has agreed upon the symbols or plan notations, as they are called, which are reproduced in Figs. 154 to 159, and they are in general used today.

2. Figure 160 illustrates the application of plan notations to an industrial plant map, colors to show different types of construction alone being omitted. A little study will show that dozens of facts are recorded.

3. This figure also has value in that it illustrates good fire protection for a plant of this kind and what is good practice in the protection of openings in fire walls, outside walls, and vertical shafts.

4. Engineers who do field work find it essential to know the standard plan notations in order that they may rapidly and accurately record the data they secure, and in order that the information they gather may be easily interpreted by others and converted into plans as a permanent record valuable both from an insurance and fire prevention point of view.



COLORS

Yellow: Wooden walls.

Red: Brick walls. √

Blue: Stone or Concrete walls.

Gray: Iron walls. √

Brown: Fire resistive construction.

Brown (Mottled): Reinforced concrete construction.

If hollow block concrete, so mark.

When walls are not of a single material, use the proper colors in combination.

Exposure: Color in outline.

Wood platform: Cross hatch in yellow.

Water courses: Light blue.

CORNICES, ROOFS, ETC.

4 Sto. Bsmt. & Attic in height.

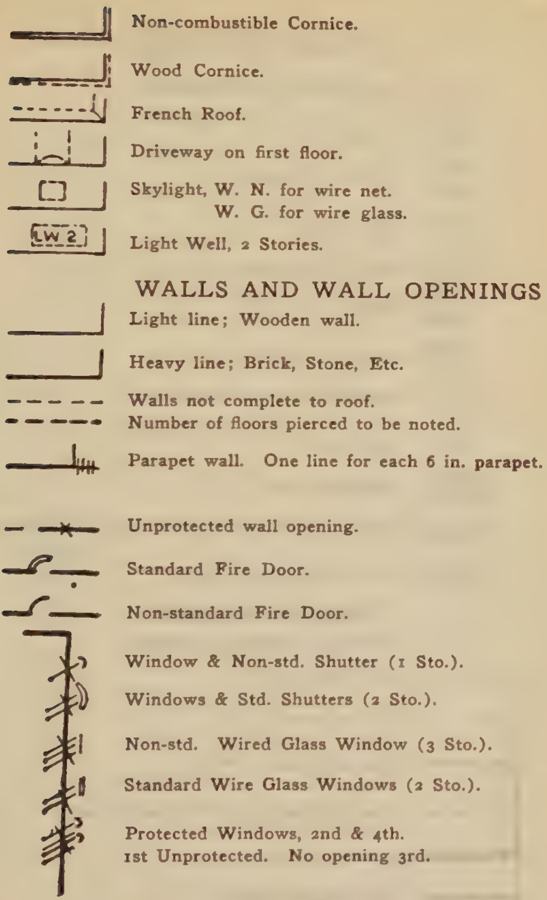
Height of Bldg. in feet.

Composition Roof.

Metal, Tile, or Slate Roof.

Shingle Roof.

Fig. 154. Standard Plan Notations.


Non-combustible Cornice.
Wood Cornice.
French Roof.
Driveway on first floor.
Skylight, W. N. for wire net.
W. G. for wire glass.
LW 2
Light Well, 2 Stories.
WALLS AND WALL OPENINGS
Light line; Wooden wall.
Heavy line; Brick, Stone, Etc.
Walls not complete to roof.
Number of floors pierced to be noted.
Parapet wall. One line for each 6 in. parapet.
Unprotected wall opening.
Standard Fire Door.
Non-standard Fire Door.
Window & Non-std. Shutter (1 Sto.).
Windows & Std. Shutters (2 Sto.).
Non-std. Wired Glass Window (3 Sto.).
Standard Wire Glass Windows (2 Sto.).
Protected Windows, 2nd & 4th.
1st Unprotected. No opening 3rd.

Dot represents openings counting from left to right looking toward Building.

FIG. 155. STANDARD PLAN NOTATIONS.

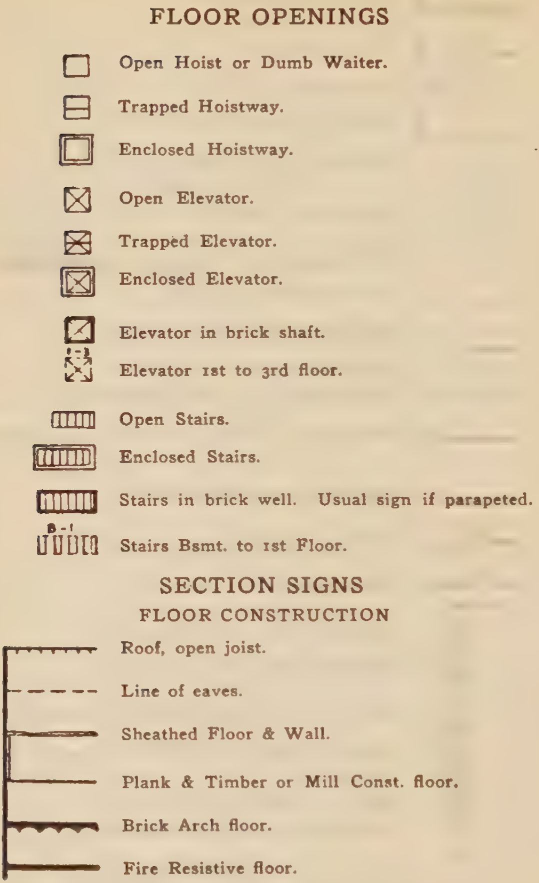


FIG. 156. STANDARD PLAN NOTATIONS.

MISCELLANEOUS

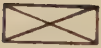
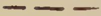
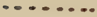
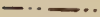
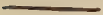
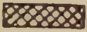
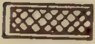
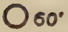
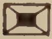
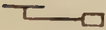
	Underground Gasolene Tank; dotted circle.
	Stable. D. Dwlg. S. Store.
	Open Sheds.
	Platforms, Also Bridge or Tunnel if so labelled.
	Property Line.
	Fence.
(47)	Grade above sea level (feet).
30'	Width of Street (feet).
	Street Number.
	Boiler not bricked in.
	Boiler bricked in.
	Vertical Boiler.
	Iron Stack 60 Feet high.
	Brick Chimney.
	Fire Alarm Box.
	Engine.
	Dynamo.
	Motor.

FIG. 157. STANDARD PLAN NOTATIONS.

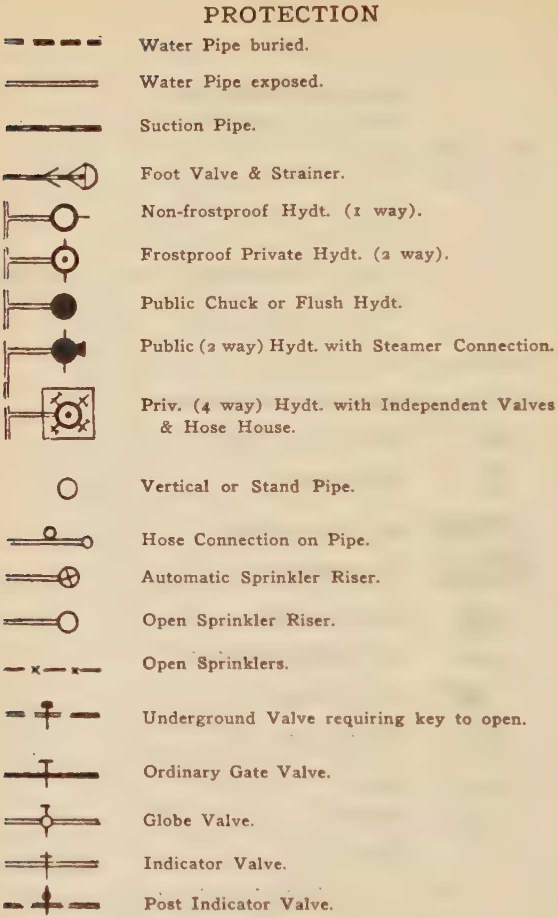

PROTECTION
Water Pipe buried.
Water Pipe exposed.
Suction Pipe.
Foot Valve & Strainer.
Non-frostproof Hydt. (1 way).
Frostproof Private Hydt. (2 way).
Public Chuck or Flush Hydt.
Public (2 way) Hydt. with Steamer Connection.
Priv. (4 way) Hydt. with Independent Valves & Hose House.
Vertical or Stand Pipe.
Hose Connection on Pipe.
Automatic Sprinkler Riser.
Open Sprinkler Riser.
Open Sprinklers.
Underground Valve requiring key to open.
Ordinary Gate Valve.
Globe Valve.
Indicator Valve.
Post Indicator Valve.

FIG. 158. STANDARD PLAN NOTATIONS.

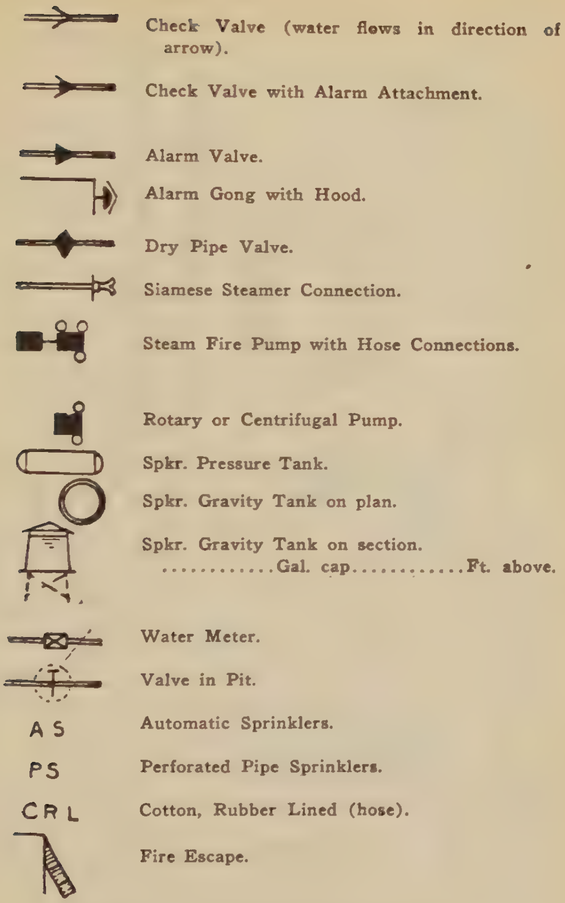

Check Valve (water flows in direction of arrow).
Check Valve with Alarm Attachment.
Alarm Valve.
Alarm Gong with Hood.
Dry Pipe Valve.
Siamese Steamer Connection.
Steam Fire Pump with Hose Connections.
Rotary or Centrifugal Pump.
Spkr. Pressure Tank.
Spkr. Gravity Tank on plan.
Spkr. Gravity Tank on section.
............Gal. cap............Ft. above.
Water Meter.
Valve in Pit.
A S
Automatic Sprinklers.
P S
Perforated Pipe Sprinklers.
C R L
Cotton, Rubber Lined (hose).
Fire Escape.

FIG. 159. STANDARD PLAN NOTATIONS.

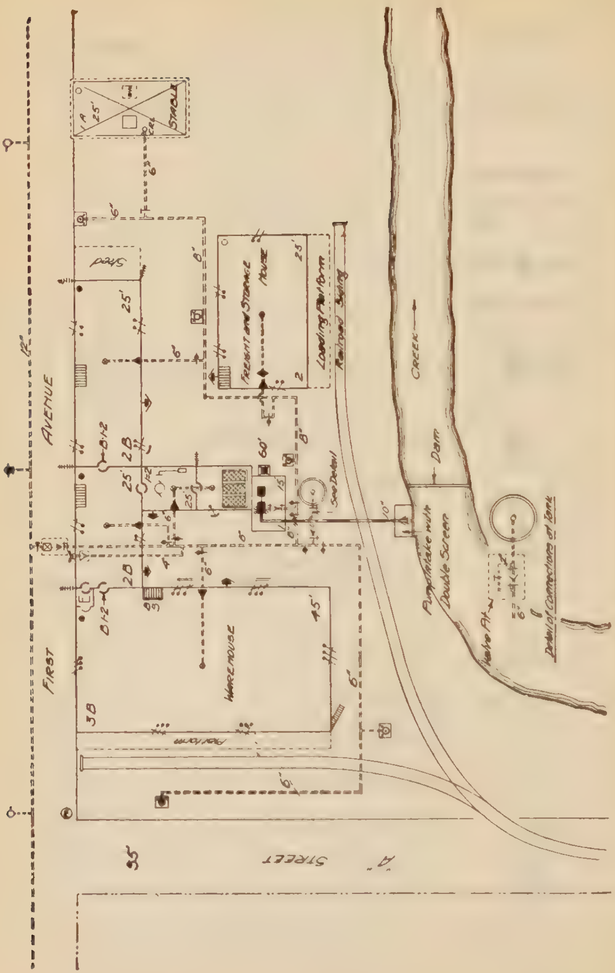


FIG. 160. DIAGRAM SHOWING USE OF STANDARD PLAN NOTATIONS.

CHAPTER 41

THE TABLES AND HOW TO USE THEM

1. Long experience has shown that the tables in this section of the Handbook include substantially all data that the fire protection engineer is likely to need in field examinations and tests, in reviewing plans, and in planning new fire protection layouts. As indicated in the Table of Contents, the tables are grouped in the following divisions:

a—**Friction Data and Flowing Tests,** covering data regarding pipes, meters, valves and fittings, hose, nozzles, hydrant butts, and sprinklers.

b—**Capacities,** covering vertical and horizontal cylindrical tanks, typical dimensions of various types of tanks, reservoirs, reciprocating and rotary pumps, piping, and sprinkler systems.

c—**Miscellaneous,** covering static pressures, hydraulic rules, metric conversion tables, melting and flashpoints of substances, data regarding gases, comparative thermometer tables, freezing temperature records, and automatic sprinkler fire record.

d—**Curves,** covering in graphic form the data most frequently needed by the fire protection engineer, namely:

Fig. 161—Friction of Water in Pipes.
Fig. 162—Effective Range of Fire Streams.
Figs. 163 and 164—Small Hose Stream Range and Discharge.
Fig. 165—Theoretical Discharge Through Circular Outlets.
Fig. 166—Hose Stream Data (Selected from Freeman Table).
Fig. 167—Hose Stream Data (Selected from National Board Tables).
Fig. 168—Discharge from Sprinklers.

Fig. 169—Necessary Excess Pressure for Pressure Tanks.
Fig. 170—Amount of Water and Air Pressure in Pressure Tanks.
Fig. 171—Melting Points of Various Substances.
Fig. 172—Range of Temperatures.

2. The functions of most of the tables will be self-evident, but a word of explanation regarding certain points may not be out of order.

Table 3.

3. Table 3, Relative Discharge Capacities of Pipes, shows the number of pipes of a smaller size needed to carry between them the same amount of water as a larger pipe and with same friction loss. For example: the ratio of 8″ to 4″ pipe is 5.66. Referring to Table 1, we find, with a flow of 500 gallons per minute, that the friction losses for 8″ and 4″ pipes respectively are .22 and 6.40 lbs. If 5.66—4″ pipes carry 500 gallons between them, each would carry 88 gallons. The loss in 4″ pipe for such a flow lies between .19 and .33 lbs., or fairly close to .22, quite as close as hydraulic tables can be expected to come.

Table 6.

4. This table of friction losses in fire hose is particularly valuable, because it covers 3″, 3½″, and 2 lines of 2½″ hose siamesed, as well as 2½″ cotton rubber-lined hose. The table also carries the flows up to a high rate in gallons per minute.

5. A comparison with the Freeman Table No. 15, covering also 100-ft. lines of hose, shows fairly good agreement between these sets of tests, made something like twenty years apart. It is fair to assume that the later National Board tests more nearly represent the frictions encountered with modern best quality of fire hose, and where hose friction data is desired, Table 6 can be safely and, because of its form, most conveniently followed.

Table 9.

6. The effective horizontal and vertical reaches of fire streams given in this table are conservative in the sense that it is often possible to do fairly effective work at greater distances than those specified. The important point to bear in mind, however, is that a fire stream is most effective when it strikes the burning material in solid form.

Tables 14, 15, 16, and 17.

7. These famous Freeman Pump Inspection tables have for approximately 35 years constituted the foundation of fire protection engineering practice in so far as hose and hydrant frictions have been concerned. In conjunction with other Freeman tables they have furnished practically all of the information that was necessary to handle the hydraulic problems in connection with fire protection engineering. The only valuable additions to the available knowledge have been the more recent tests of the National Board of Fire Underwriters, which have been published in a booklet entitled "Fire Engine Tests and Fire Stream Tables."

8. The selected data appearing in graphic form in Fig. 166 probably will prove ample to the needs of fire protection engineers when conducting the ordinary field tests.

9. These four tables give a very considerable variety as to hydrant pressures and sizes of nozzle and some variety as regards length of hose. It will be noted that 150-ft. lines were the longest employed where nozzles were attached, and that the open hose butt tests have been run with lengths as great as 400 ft.

Friction Tests and Calculations.

10. The elements that enter into the ordinary friction tests or calculations of a water system are as follows:

a—Hydrant pressure with water flowing.

b—Friction loss in hose.

c—Nozzle discharge pressure.

d—Gallons discharged through each hose line.

11. Tables 14 to 17 inclusive give "a" and "d" directly and show the size of the nozzle or hose coupling through which water was discharged. By referring to Table 12 and 13, it is readily possible to ascertain the pressure at the nozzle necessary to discharge the given quantities of water. Subtracting the nozzle pressures thus ascertained from the hydrant pressures, the friction loss in hose is obtained.

12. While it is always desirable to obtain both the hydrant pressures and the nozzle pressures, securing either pressure, where lengths of hose lines, size of hose, approximate condition of lining, and kind and size of nozzle are known, will answer very well indeed.

13. A common problem is to ascertain the drop in pressure between the source of water supply and the hydrant from which water is flowing. Where facilities are not available for attaching a gage to the hydrant, or where all hydrant outlets must be used for hose lines, the results secured are quite accurate if the nozzle pressure is taken, friction calculated back to the hydrant, and the pressure so established subtracted from the known pressure at the point of supply, as, for example, fire pump or connection to a street main.

14. In this connection see data on methods of making water tests found on page 316.

15. See also data below in regard to Table 19.

Table 18.

16. The Open Hydrant Butts Pump Inspection tables are admittedly far less accurate than the data secured by hose streams, and open hydrant butt tests should not be used if it is possible to avoid doing so. The open butt test, however, is permissible under the following conditions:

a—As the final test of a series in which the amount of water drawn from the system is gradually increased.

b—As a rough test when facilities for laying hose lines do not exist.

17. The best results are obtained if a gage is screwed into a hydrant cap attached opposite the open butt, but if such facilities are not available or if hydrant has only a single outlet, a Pitot tube can be used with fairly good results. It is necessary, however, to exercise care to get an average Pitot tube reading, as the pressures will vary considerably at different points in the stream.

18. The Freeman tables give representative hydrant conditions, and any hydrant tested, not exactly like those shown, should be examined and measured to ascertain which of the illustrated forms of outlets it most closely resembles.

Table 19.

19. This National Board Engine Test Hose Stream table is in one sense of the word the reverse of Tables 14 to 17. The

Freeman tables start with the hydrant pressure, and the National Board table with the nozzle pressure. It is to be noted that the table here shown gives but a small fraction of all the data included in the very excellent National Board booklet.

20. These tables are particularly valuable because the water supply problem commonly is one of ascertaining how much pressure must be maintained at the hydrant or engine with a given nozzle pressure, the nozzle pressure being arbitrarily established by the probable conditions of fire fighting. The table gives the nozzle pressure, the gallons discharged, and the hydrant or engine pressures for various lengths of hose and with various size nozzles. By subtraction, the hose frictions are readily ascertained.

21. See Table of Contents for a list of the tables on the following pages.

TABLE I

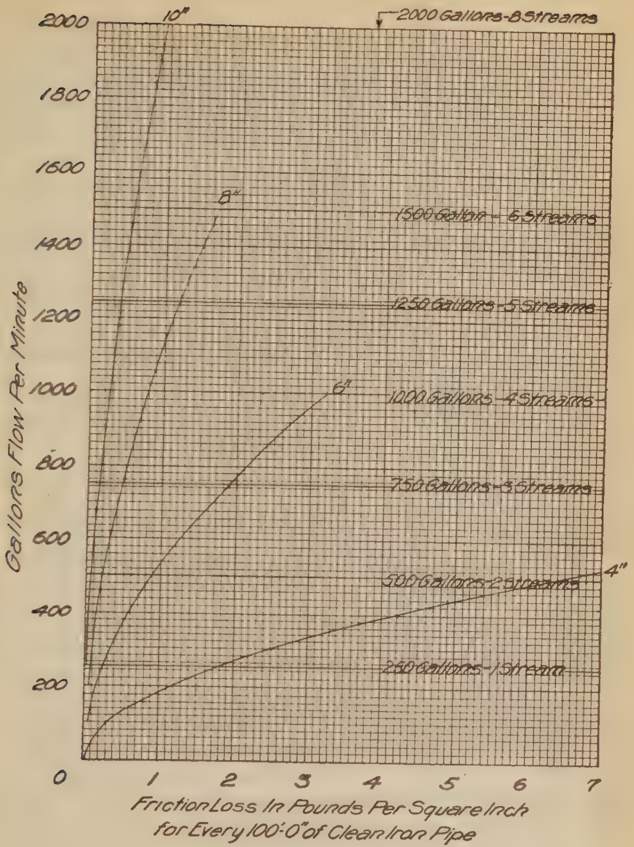
FRICTION OF WATER IN PIPES IN POUNDS LOSS

Friction loss in pounds pressure per square inch for each 100 feet of length of different size clean iron pipe discharging given quantities of water per minute. From Hazen & Williams Hydraulic Tables.

Pipes 4 inches in diameter and larger which have been in service 10 to 15 years will ordinarily show a friction loss approximately 50 per cent. greater than that given in the table; pipes which have been longer in service or which have been especially subjected to corrosion may show 100 per cent. or more increase in friction loss.

Gallons per Minute	Sizes of Pipes—Inside Diameter.														
	¾ In.	1 In.	1¼ In.	1½ In.	2 In.	2½ In.	3 In.	4 In.	6 In.	8 In.	10 In.	12 In.	14 In.	16 In.	18 In.
5	3.2	1.0	0.27	0.12	..	....	...	....	....	....	....	....	....	....	....
10	11.6	3.6	0.96	0.44	0.15	....	...	....	....	....	....	....	....	....	....
15	24.8	7.7	2.0	0.94	....	....	....	....	....	....	....	....	....	....	....
20	42.0	13.1	3.5	1.6	0.56	....	....	....	....	....	....	....	....	....	....
25	63.8	19.8	5.2	2.4	....	0.29	0.12	0.025	...	....	....	....	....	....	....
30	....	27.8	7.3	3.4	1.18	....	....	....	....	....	....	....	....	....	....
35	...	37.0	9.8	4.5	....	....	....	....	....	....	....	....	....	....	....
40	...	47.2	12.5	5.8	2.00	....	0.28	....	....	....	....	....	....	....	....
45	...	....	15.5	7.2	....	....	....	....	....	....	....	....	....	....	....
50	....	....	19.9	8.8	3.05	1.04	0.43	0.09	...	....	....	....	....	....	....
75	...	....	40.0	18.5	5.72	2.20	0.90	0.19	....	....	....	....	....	....	....
100	...	...	....	31.6	11.0	3.72	1.55	0.33	0.05	....	....	....	....	....	....
150	...	...	...	....	23.3	8.00	3.3	0.69	0.09	....	...	....	....	....	....
200	...		...	....	39.8	13.50	5.6	1.17	0.16	....	...	....	....	....	....
250	—	—	—	—	—	**20.2**	**8.4**	**1.77**	**0.25**	**0.06**	**0.02**	—	—	—	—
300	....	...	...	...	....	28.6	11.8	2.50	0.34	0.09	....	....	....	....	....
350	...	...	...	....	...	....	15.7	3.30	0.46	0.11	....	....	....	....	....
400	...	...	...	....	...	....	20.0	4.20	0.58	0.15	0.05	....	....	....	....
450	...	...	...	....	...	....	25.0	5.20	0.73	0.18	....	....	....	....	....
500	—	—	—	—	—	—	**30.3**	**6.40**	**0.90**	**0.22**	**0.07**	**0.03**	**0.014**	**0.008**	**0.004**
600	...	...	...	....		.	....	9.00	1.25	0.31	0.10	....	....	....	....
700	...	...	....	....	...	....	..	11.90	1.65	0.41	0.14	0.06	....	....	....
750	—	—	—	—	—	—	—	—	**1.9**	**0.47**	**0.15**	—	—	—	—
800	...	...	...	...	...	.	.	...	2.1	0.52	0.18	....	....	....	....
900	....	....	...	...	...	...	.	.	2.6	0.65	0.22	0.09	....	....	....
1,000	—	—	—	—	—	—	—	—	**3.2**	**0.79**	**0.27**	**0.11**	**0.05**	**0.27**	**0.015**
1,250	...	...	....	....	.		.	.	.	1.20	0.40	0.16	....	....	....
1,500	...	...	..	....	.		.	....	....	1.68	0.56	0.23	0.11	0.06	0.032
2,000	—	—	—	—	—	—	—	—	—	—	**0.95**	**0.39**	**0.18**	**0.10**	**0.055**
2,500	...	...	...	...	...	...	...	....	...	.	....	0.59	0.27	0.15	0.083
3,000	...	...	...	....	...	....	....	....	....	....	....	0.83	0.38	0.21	0.115
3,500	....	....	....	....	....	....	....	....	....	....	....	....	0.51	0.28	0.155
4,000	....	....	....	....	....	....	....	....	....	....	....	....	0.66	0.35	0.20

TABLE 1. DIAGRAM



Note. Pipes of 4" or larger show approximately 50% greater friction loss after being in service 10 or 15 years.

FIG. 161. FRICTION OF WATER IN PIPES.
(Extracts from Table 1.)

TABLE 2

FRICTIONAL HEADS AT GIVEN RATES OF DISCHARGE IN CLEAN CAST IRON PIPES. FOR EACH 1,000 FEET OF LENGTH

(Courtesy of R. D. Wood and Co.)

U.S. Gallons Discharged per Minute.	4-inch Pipe.			6-inch Pipe.			8-inch Pipe.			10-inch Pipe.			12-inch Pipe.			14-inch Pipe.		
	Velocity in Feet.	Fric. Head.		Velocity in Feet.	Fric. Head.		Velocity in Feet.	Fric. Head.		Velocity in Feet.	Fric. Head.		Velocity in Feet.	Fric. Head.		Velocity in Feet.	Fric. Head.	
		Feet.	Lbs.		Feet.	Lbs.		Feet.	Lbs.		Feet.	Lbs.		Feet.	Lbs.		Feet.	Lbs.
100	2.55	7.36	3.19	1.13	1.08	.47	.64	.29	.13	.41	.11	.05	.28	.05	.02	.21	.03	.01
150	3.83	16.05	6.95	1.70	2.28	.99	.96	.60	.26	.61	.22	.10	.43	.10	.04	.31	.05	.02
200	5.11	28.09	12.17	2.27	3.92	1.70	1.28	1.01	.44	.82	.36	.16	.57	.16	.07	.42	.08	.04
250	6.37	43.47	18.83	2.84	6.00	2.60	1.60	1.52	.66	1.02	.54	.23	.71	.24	.10	.52	.12	.05
300	7.66	62.20	26.94	3.40	8.52	3.69	1.91	2.13	.92	1.23	.75	.32	.85	.32	.14	.63	.16	.07
350	8.94	84.26	36.50	3.97	11.48	4.97	2.23	2.85	1.24	1.43	.99	.43	.99	.43	.18	.73	.21	.09
400	10.21	109.68	47.50	4.54	14.89	6.45	2.55	3.68	1.59	1.63	1.27	.55	1.13	.54	.23	.83	.27	.12
450	11.49	138.43	59.96	5.11	18.73	8.11	2.87	4.61	2.00	1.83	1.58	.69	1.28	.07	.29	.94	.33	.14
500	12.77	170.53	73.87	5.67	23.01	9.97	3.19	5.64	2.44	2.04	1.93	.84	1.42	.81	.35	1.04	.40	.17
600	15.32	244.76	106.02	6.81	32.89	14.25	3.83	8.03	3.48	2.45	2.72	1.18	1.70	1.14	.49	1.25	.55	.24
700	17.87	332.36	143.98	7.94	44.54	19.08	4.47	10.83	4.69	2.86	3.66	1.58	1.98	1.52	.66	1.46	.73	.32
800				9.08	57.95	25.10	5.09	14.05	6.08	3.27	4.73	2.05	2.27	1.96	.85	1.67	.94	.41
900				10.21	73.12	31.67	5.74	17.68	7.69	3.68	5.93	2.57	2.55	2.45	1.06	1.88	1.17	.51
1,000				11.35	90.05	38.99	6.38	21.74	9.41	4.08	7.28	3.15	2.84	3.00	1.30	2.08	1.43	.62
1,200				13.61	129.20	55.96	7.66	31.10	13.47	4.90	10.38	4.50	3.40	4.26	1.85	2.50	2.02	.88
1,400				15.88	175.38	75.97	8.94	42.13	18.25	5.72	14.02	6.07	3.97	5.74	2.49	2.91	2.72	1.18
1,600				18.15	228.62	99.03	10.21	54.84	23.75	6.53	18.22	7.89	4.54	7.44	3.22	3.33	3.51	1.52
1,800				20.42	288.90	125.14	11.47	69.22	29.98	7.35	22.96	9.95	5.11	9.36	4.06	3.75	4.41	1.91
2,000				22.69	356.22	154.30	12.77	85.27	36.93	8.17	28.25	12.34	5.67	11.50	5.00	4.17	5.41	2.34
2,500							15.96	132.70	57.49	10.21	43.87	19.00	7.09	17.82	7.72	5.21	8.35	3.62
3,000										12.25	62.92	27.25	8.51	25.51	11.05	6.25	11.92	5.17
3,500													9.93	34.58	14.98	7.29	16.14	6.99
4,000																8.34	21.00	9.10
4,500																9.38	26.49	11.47

TABLE 2—EXPLANATION

The loss in head data on the opposite page is a portion of the R. D. Wood and Company tables which are carried to 36″ pipe and 20,000 gallons per minute discharge.

Note: This table is based on 1,000 feet of pipe; table 1 on 100 feet.

Table 2 may be used in the following ways:

DETERMINING FRICTION HEAD FOR GIVEN DICHARGE

This is ascertained by a direct reading, and is the most likely question to be raised in fire protection lay outs.

DETERMINING FLOW FROM REDUCTION IN PRESSURE

Knowing the loss in pressure between two points, the distance between them, and the size of pipe, the friction head may be reduced to a 1,000-ft. basis; then the data desired is easily obtained from the table.

DETERMINING PIPE DIAMETER FROM KNOWN DISCHARGE AND FRICTION HEAD

After reducing friction head to a 1,000-ft. basis, look along the proper "gallons discharged" line to find the friction head nearest that determined by test. The corresponding pipe diameter will be the one sought.

DETERMINING MAXIMUM DISCHARGE UNDER KNOWN HEAD

Reduce the friction head to a 1,000-ft. basis, and then for any given pipe size find the nearest friction head. Then read the maximum discharge obtainable under the conditions.

TABLE 3

RELATIVE DISCHARGE CAPACITIES OF PIPES

This table takes into consideration the impeding of the flow of water by imperfections in the interior surface of the pipes due to corrosive and incrusting action of the water or other causes. (From R. D. Wood & Co.'s catalogue.)

Diameter in Inches												Diameter in Inches.
3	4	6	8	10	12	14	16	18	20	22	24	
.....	.....	32.00	15.59	8.92	5.66	3.85	2.76	2.05	1.58	1.24	1.	24
.....	71.00	25.74	12.54	7.18	4.55	3.10	2.22	1.65	1.27	1.	...	22
.....	55.94	20.28	9.88	5.66	3.59	2.44	1.75	1.30	1.	.....	....	20
.....	43.00	15.59	7.59	4.35	2.76	1.87	1.34	1.	.....	.....	....	18
65.80	32.03	11.61	5.66	3.24	2.05	1.40	1.	.....	.....	.....	....	16
47.12	22.93	8.31	4.05	2.32	1.47	1.	.....	.....	.....	.....	....	14
32.05	15.60	5.66	2.76	1.58	1.	.....	.....	.....	.....	.....	....	12
20.32	9.89	3.59	1.75	1.	.....	.....	.....	.....	.....	.....	....	10
11.63	5.66	2.05	1.	.....	.....	.....	.....	.....	.....	.....	....	8
5.66	2.76	1.	.....	.....	.....	.....	.....	.....	.....	.....	....	6
2.05	1.	.....	.....	.....	.....	.....	.....	.....	.....	.....	....	4
1.	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	....	3

The last vertical column gives the diameters in inches, as does also the horizontal column at the head of the table.

The numbers at the intersections of the diameters in inches of the horizontal and vertical columns give the approximate relative discharging capacities. For instance, if it is desired to know how many smaller pipes a 12-inch pipe is equal to in discharging capacity, trace along the horizontal line from the 12-inch diameter in the vertical column, and it will be found that it is equal to 15.60 4-inch pipes, or 2.76 8-inch pipes, etc.

TABLE 4

FRICTION LOSS IN VALVES AND FITTINGS

(From tests of the Associated Factory Mutual Fire Insurance Companies.) Data of more general usefulness is as follows:

Object Tested	Equivalent Straight Pipe of same Diameter
Long Turn Ells	4 feet
Short Turn Ells	9 feet
Long Turn Tees	9 feet
Short Turn Tees	17 feet
6″ Straight Way Check	50 feet
4″ Straight Way Check	25 feet
6″ Differential Dry Pipe Valve (average)	20 feet
6″ English Alarm Check	100 feet
4″ English Alarm Check	47 feet

Note: 1922 Bulletin of University of Wisconsin, Engineering Series Vol. IX, No. 1, contains exhaustive data regarding loss of head in valves and pipes of ½″ to 12″ in diameter.

TABLE 5

FRICTION LOSSES IN METERS

Name and Type of Meter.	Size of Meter.	Loss of Pressure in Pounds Caused by Meter.									Year of Test.
		Gallons per Minute Flowing.									
		100	250	500	750	1000	1250	1500	2000	2500	
DISC											
Lambert	4 in.	0.6	3.5	12.9	28.6	......	......	......	....	....	1896–97
Hersey...................	6 in.	0.2	1.5	6.2	13.9	24.8	38.7	......	....	....	1903
Keystone	6 in.	0.1	0.8	3.3	7.5	13.4	20.9	30.1	....	....	1903
*Nash	6 in.	0.6	1.3	5 5	13.3	24.0	......	......	....	....	1903
ROTARY PISTON											
*Hersey	4 in.	1.6	9.3	40.0	......	......	......	......	....	....	1896–97
*Crown......	4 in.	1.4	7.5	31.2	......	......	......	......	....	....	1896–97
Union	4 in.	0.2	1.7	6.5	14.6	25.5	......	......	....	....	1896–97
Hersey	6 in.	0.5	3.0	11.9	26.9	47.8	......	......	....	....	1903
*Crown.......	6 in.	0.4	2.4	9.6	21.5	38.2	59.8	......	....	....	1903
Empire	6 in.	0.3	2.1	8.2	18.6	33.2	51.6	......	....	....	1903
Union	6 in.	0.1	0.3	1.4	3.1	5.6	8.7	12.5	22.3	....	1904
Union	6 in.	0.1	0.5	2.1	4.6	8.2	13.1	20.4	(Single screen in fish trap.)		1904
Union	6 in.	0.1	0.5	2.5	6.0	10.2	16.2	23.9	(D'ble screen in fish trap.)		1904
CURRENT											
*Gem..................	4 in.	0.0	1.1	4.1	9.5	......	......	......	....	....	1896–97
Torrent................	4 in.	0.2	2.0	8.1	18.9	......	......	......	....	....	1896–97
Gem	6 in.	0.0	0.3	1.0	2.2	4.0	6.2	9.0	15.9	24.9	1903
*Torrent..............	6 in.	0.1	0.5	2.2	4.9	8.7	13.5	19.5	34.6	....	1903
Torrent...............	6 in.	0.1	0.5	1.8	4.2	7.4	11.6	16.7	29.6	....	1903
†Standard..	6 in.	0.0	0.2	0.9	2.1	3.7	5.8	8.4	15.0	23.4	1903
‡Standard.............	6 in.	0.0	0.2	0.7	1.5	2.7	4.2	6.1	10.8	16.8	1903
*Crest	6 in.	0.1	0.4	1.7	3.8	6.9	10.9	15.5	....	....	1904
Crest	6 in.	0.0	0.3	1.2	2.8	5.0	7.7	11.2	20.0	....	1904
Torrent.................	8 in.	0.0	0.0	0.7	1.6	2.8	4.5	6.4	....	....	1896–97
*Torrent..............	10 in.	0.0	0.1	0.35	0.7	1.45	2.2	3.2	5.6	8.8	1904
RECIPROCATING PISTON											
Worthington	6 in.	0.3	1.4	5.6	13.0	23.0	......	......	....	....	1897–98
BY-PASSED CHECK											
Hersey D. M.........	4 in.	0.5	0.52	0.55	1.2	2.0	......	......	....	....	
" "	6 in.	1.3	0.5	0.5	0.5	0.5	0.65	0.9	1.75	2.5	Since 1905
" "	8 in.	0.87	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.8	
" "	10 in.	0.5	2.2	0.5	0.5	0.5	0.5	0.5	0.5	0.5	
" "	12 in.	0.2	2.0	0.5	0.5	0.5	0.5	0.5	0.5	0.5	
Hersey F. M.........	4 in.	0.57	0.75	1.25	2.8	5.0	......	......	....	....	
" "	6 in.	1.7	0.55	0.7	0.85	1.00	1.66	2.3	4.2	6.4	Since 1909
" "	8 in.	1.00	0.55	0.6	0.7	0.75	0.8	0.9	1.3	2.0	
" "	10 in.	0.24	2.0	0.58	0.6	0.65	0.7	0.75	0.82	0.95	
" "	12 in.	0.22	1.7	0.5	0.55	0.6	0.62	0.65	0.7	0 8	
Neptune Protectus.	6 in.	1.6	3.5	3.8	3.2	2.9	2.7	2.6	....	....	1914
PLAIN CHECK	4 in.	0.0	0.1	0.6	1.3	2.3	......	......	....	....	....
" "	6 in.	0.0	0.1	0.28	0.70	1.20	......	......	....	....	....
FACTORY MUTUAL.	6 in.	2.4	1.4	1.6	2.1	2.4	3.2	4.5	7.6	11 8	1907

Meters marked thus * were equipped with fish traps at time of test; the others had no traps.

† Aluminum paddles.

‡ Copper paddles.

Since the above tests, modifications may have been made in some of the meters, possibly changing the friction losses somewhat.

Larger quantities of water were forced through the meters in some of the tests than proper in every day use, to determine the friction loss under extreme conditions.

TABLE 6

FRICTION LOSSES IN FIRE HOSE

Based on Tests of Best Quality Rubber-Lined Fire Hose.*

Flow, Gallons per Minute.	PRESSURE LOSS IN EACH 100 FEET OF HOSE, POUNDS PER SQ. INCH.				Flow, Gallons per Minute	PRESSURE LOSS IN EACH 100 FEET OF HOSE, POUNDS PER SQ. INCH.		
	2½" Hose.	3" Hose.	3½" Hose.	2 Lines of 2½" Siamesed.		3" Hose.	3½" Hose.	2 Lines of 2½" Siamesed.
140	5.2	2.0	0.9	1.4	525	23.2	10.5	16.6
160	6.6	2.6	1.2	1.9	550	25.2	11.4	18.1
180	8.3	3.2	1.5	2.3	575	27.5	12.4	19.0
200	10.1	3.9	1.8	2.8	600	29.9	13.4	21.2
220	12.0	4.2	2.1	3.3	625	32.0	14.4	23.0
240	14.1	5.4	2.5	3.9	650	34.5	15.5	24.8
260	16.4	6.3	2.9	4.5	675	37.0	16.6	26.5
280	18.7	7.2	3.3	5.2	700	39.5	17.7	28.3
300	21.2	8.2	3.7	5.9	725	42.3	18.9	30.2
320	23.8	9.3	4.2	6.6	750	45.0	20.1	32.2
340	26.9	10.5	4.7	7.4	775	47.8	21.4	34.2
360	30.0	11.5	5.2	8.3	800	50.5	22.7	36.2
380	33.0	12.8	5.8	9.2	825	53.5	24.0	38.4
400	36.2	14.1	6.3	10.1	850	56.5	25.4	40.7
425	40.8	15.7	7.0	11.3	875	59.7	26.8	43.1
450	45.2	17.5	7.9	12.5	900	63.0	28.2	45.2
475	50.0	19.3	8.7	13.8	1,000	76.5	34.3	55.0
500	55.0	21.2	9.5	15.2	1,100	91.5	41.0	65.5

* Rough rubber lining is liable to increase the losses given in the tables as much as 50 per cent.

From "Fire Engine Tests and Hose Stream Tables" by National Board of Fire Underwriters.

TABLE 7

COMPARATIVE FRICTION LOSSES IN FIRE HOSE

(From Experiments of J. R. Freeman)

In pounds per one hundred feet, with various amounts flowing. Nominal diameter 2½ inches; actual approaches 2⅝ inches.

	Gallons Flowing.					
	100.	150	200.	250.	300.	350.
Unlined linen..........	5	12	21	33	46	62
Rubber-lined, fair.......	4	10	18	29	40	54
Rubber-lined, good......	2	5	9	14	20	27

The ratio of friction losses of large hose and 2½-in. rubber-lined hose is approximately: 3-in.—38%; 3½-in.—17%; 4-in.—9%; 4½-in.—5%; 5-in.—3%.

1920 tests of the Factory Mutual Laboratories showed friction loss per 100 ft. of hose with 250 gals. per minute flow to be 3.25 lbs. greater in 2½″ than in 2⅝″ cotton rubber-lined hose.

TABLE 8

RELATIVE DISCHARGE CAPACITIES OF NOZZLES

Number of Nozzles.												
1	5/8″	3/4″	7/8″	1″	1 1/8″	1 1/4″	1 3/8″	1 1/2″	1 5/8″	1 3/4″	1 7/8″	2″
2	7/8″	1 1/16″	1 1/4″	1 3/8″	1 5/8″	1 3/4″	1 15/16″	2 1/8″	2 5/16″	2 1/2″	2 5/8″	2 13/16″
3	1 1/16″	1 5/16″	1 1/2″	1 3/4″	1 15/16″	2 3/16″	2 3/8″	2 5/8″	2 13/16″	3″	3 1/4″	3 1/2″
4	1 1/4″	1 1/2″	1 3/4″	2″	2 1/4″	2 1/2″	2 3/4″	3″	3 1/4″	3 1/2″	3 3/4″	4″
5	1 3/8″	1 11/16″	2″	2 1/4″	2 1/2″	2 3/4″	3 1/16″	3 3/8″	3 5/8″	3 15/16″	4 3/16″	
6	1 1/2″	1 13/16″	2 1/8″	2 7/16″	2 3/4″	3 1/16″	3 3/8″	3 11/16″	4″			
7	1 5/8″	2″	2 5/16″	2 5/8″	3″	3 5/16″	3 5/8″	4″				
8	1 3/4″	2 1/8″	2 1/2″	2 13/16″	3 3/16″	3 9/16″	3 7/8″					
9	1 7/8″	2 1/4″	2 5/8″	3″	3 3/8″	3 3/4″	4 1/4″					
10	2″	2 3/8″	2 3/4″	3 3/16″	3 9/16′	4″						
11	2 1/16″	2 1/2″	2 7/8″	3 5/16″	3 3/4″							
12	2 3/16″	2 5/8″	3″	3 1/2″	3 15/16″							

Method of Using—To find which size nozzle equals two 1⅛-inch nozzles: On the line marked 2, the size nozzle (1⅝) in the column 1⅛″ will be the corresponding size.

TABLE 9

EFFECTIVE RANGE OF FIRE STREAMS

Showing the Distance in Feet from the Nozzle at which Streams will do Effective Work with a Moderate Wind Blowing. With a Strong Wind the Reach is Greatly Reduced.

Pressure at Nozzle.	Size of Nozzle.									
	1-Inch.		1⅛-Inch		1¼-Inch.		1⅜-Inch.		1½-Inch.	
	Vertical Distance, Feet.	Horizontal Distance, Feet.	Vertical Distance, Feet.	Horizontal Distance, Feet.	Vertical Distance, Feet.	Horizontal Distance, Feet.	Vertical Distance, Feet.	Horizontal Distance, Feet.	Vertical Distance, Feet.	Horizontal Distance, Feet.
20	35	37	36	38	36	39	36	40	37	42
25	43	42	44	44	45	46	45	47	46	49
30	51	47	52	50	52	52	53	54	54	56
35	58	51	59	54	59	58	60	59	62	62
40	64	55	65	59	65	62	66	64	69	66
45	69	58	70	63	70	66	72	68	74	71
50	73	61	75	66	75	69	77	72	79	75
55	76	64	79	69	80	72	81	75	83	78
60	79	67	83	72	84	75	85	77	87	80
65	82	70	86	75	87	78	88	79	90	82
70	85	72	88	77	90	80	91	82	92	84
75	87	74	90	79	92	82	93	84	94	86
80	89	76	92	81	94	84	95	86	96	88
85	91	78	94	83	96	87	97	88	98	90
90	92	80	96	85	98	89	99	90	100	91

Note—Nozzle pressures are as indicated by Pitot tube. The horizontal and vertical distances are based on experiments by Mr. John R. Freemen, *Transactions* Am. Soc. C. E., Vol. XXI.

TABLE 9. DIAGRAM

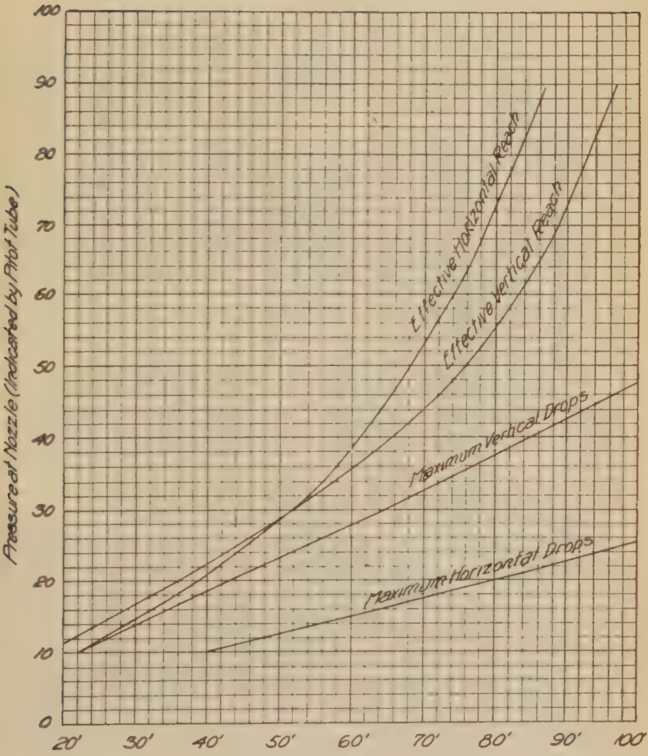


FIG. 162. EFFECTIVE RANGE OF FIRE STREAMS IN FEET
(Averages of Figures in Table 9)

TABLE 10

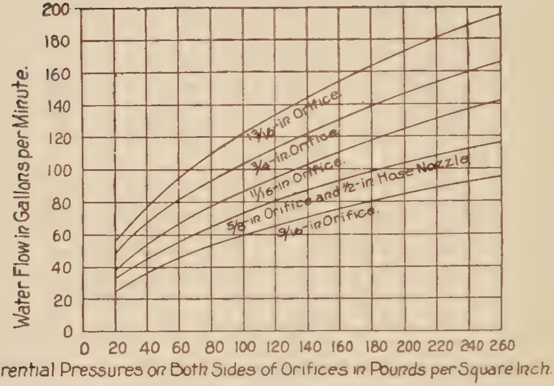
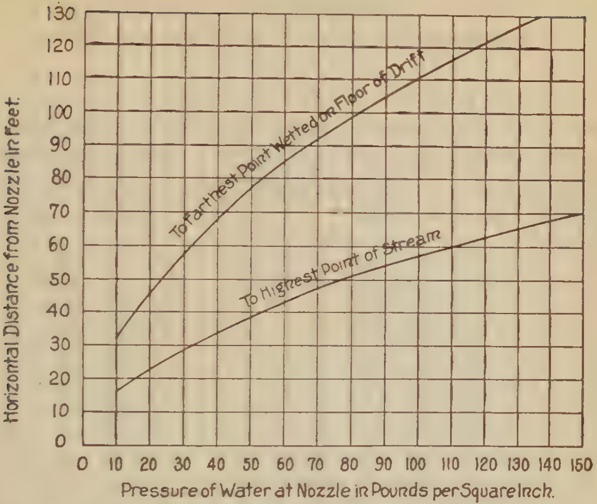


Fig. 163. High Pressure Discharge Through Small Nozzles

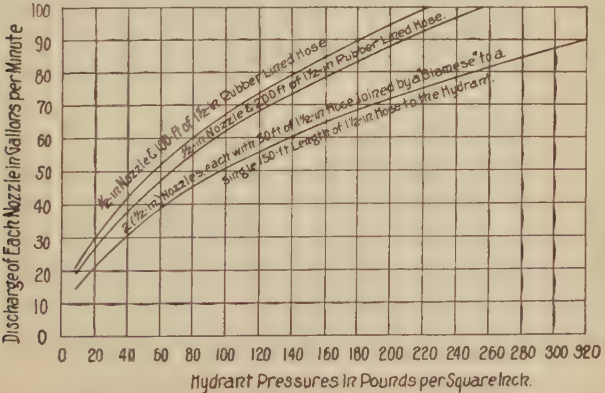
MINE FIRE STREAM DATA

Figures 163 and 164 show results of tests made under direction of Benjamin F. Tillson with underground fire system in mines of the N. J. Zinc Co. Static pressures up to 500 pounds were involved. Relatively small distributing mains were used, hose valves were bushed to give small orifices, 1½", 5-ply rubber hose was employed, and nozzle sizes ranged from ½" to 13/16". It was found that one man could safely handle ½" nozzle with flow of 90 gallons at 150 lbs. nozzle pressure, giving horizontal range under low mine head-room conditions of about 100′.

TABLE 11



Trajectory of Hose Streams from ½″ Nozzle Elevated 12 in. Above the Ground, with Maximum Height of Stream Limited to 6 ft.



Pressure Required at the Hydrant to Allow for Hose and Nozzle Friction and give Discharges shown.

Fig. 164. Range of Small High Pressure Streams

TABLE 12

DISCHARGE THROUGH SMOOTH NOZZLES

Nozzle Pressure Measured by Pitot Tube

Nozzle Pressure in lbs. per sq. inch.	Nozzle Diam. in Inches.					Nozzle Pressure in lbs. per sq. inch.	Nozzle Diam. in Inches.				
	1	1⅛	1¼	1⅜	1½		1	1⅛	1¼	1⅜	1½
	Gallons per minute.						Gallons per Minute.				
5	66	84	103	125	149	60	229	290	357	434	517
6	72	92	113	137	163	62	233	295	363	441	525
7	78	99	122	148	176	64	237	299	369	448	533
8	84	106	131	158	188	66	240	304	375	455	542
9	89	112	139	168	200	68	244	308	381	462	550
10	93	118	146	177	211	70	247	313	386	469	558
12	102	130	160	194	231	72	251	318	391	475	566
14	110	140	173	210	249	74	254	322	397	482	574
16	118	150	185	224	267	76	258	326	402	488	582
18	125	159	196	237	283	78	261	330	407	494	589
20	132	167	206	250	298	80	264	335	413	500	596
22	139	175	216	263	313	82	268	339	418	507	604
24	145	183	226	275	327	84	271	343	423	513	611
26	151	191	235	286	340	86	274	347	428	519	618
28	157	198	244	297	353	88	277	351	433	525	626
30	162	205	253	307	365	90	280	355	438	531	633
32	167	212	261	317	377	92	283	359	443	537	640
34	172	218	269	327	389	94	286	363	447	543	647
36	177	224	277	336	400	96	289	367	452	549	654
38	182	231	285	345	411	98	292	370	456	554	660
40	187	237	292	354	422	100	295	374	461	560	667
42	192	243	299	363	432	105	303	383	473	574	683
44	196	248	306	372	442	110	310	392	484	588	699
46	200	254	313	380	452	115	317	401	495	600	715
48	205	259	320	388	462	120	324	410	505	613	730
50	209	265	326	396	472	125	331	418	516	626	745
52	213	270	333	404	481	130	337	427	526	638	760
54	217	275	339	412	490	135	343	435	536	650	775
56	221	280	345	419	499	140	350	443	546	662	789
58	225	285	351	426	508	145	356	450	556	674	803
60	229	290	357	434	517	150	362	458	565	686	817

Assumed coefficient of discharge per cent. = .99 .99 .99 .99¼ .99½

Note—Coefficients of discharge are based on experiments by Mr. John R. Freeman, *Transactions* Am. Soc. C. E., Vols. XXI and XXIV.

TABLE 12

DISCHARGE THROUGH SMOOTH NOZZLES—(Continued)

Nozzle Pressure Measured by Pitot Tube

Nozzle Pressure in lbs. per sq. inch.	Nozzle Diam. in Inches. 1⅝	1¾	1⅞	2	2¼	Nozzle Pressure in lbs. per sq. inch.	Nozzle Diam. in Inches. 1⅝	1¾	1⅞	2	2¼
	Gallons per Minute.						Gallons per Minute.				
5	175	203	234	266	337	60	607	704	810	920	1167
6	192	223	256	292	369	62	617	716	823	936	1187
7	207	241	277	315	399	64	627	727	836	951	1206
8	222	257	296	336	427	66	636	738	850	965	1224
9	235	273	314	357	452	68	646	750	862	980	1242
10	248	288	330	376	477	70	655	761	875	994	1260
12	271	315	362	412	522	72	665	771	887	1008	1275
14	293	340	391	445	564	74	674	782	900	1023	1296
16	313	364	418	475	603	76	683	792	911	1036	1313
18	332	386	444	504	640	78	692	803	924	1050	1330
20	350	407	468	532	674	80	700	813	935	1063	1347
22	367	427	490	557	707	82	709	823	946	1076	1364
24	384	446	512	582	739	84	718	833	959	1089	1380
26	400	464	533	606	769	86	726	843	970	1102	1396
28	415	481	554	629	799	88	735	853	981	1115	1412
30	429	498	572	651	826	90	743	862	992	1128	1429
32	443	514	591	673	854	92	751	872	1002	1140	1445
34	457	530	610	693	880	94	759	881	1012	1152	1460
36	470	546	627	713	905	96	767	890	1022	1164	1476
38	483	561	645	733	930	98	775	900	1032	1176	1491
40	496	575	661	752	954	100	783	909	1043	1189	1506
42	508	589	678	770	978	105	803	932	1070	1218	1542
44	520	603	694	788	1000	110	822	954	1095	1247	1579
46	531	617	710	806	1021	115	840	975	1120	1275	1615
48	543	630	725	824	1043	120	858	996	1144	1303	1649
50	554	643	740	841	1065	125	876	1016	1168	1329	1683
52	565	656	754	857	1087	130	893	1036	1191	1356	1717
54	576	668	769	873	1108	135	910	1056	1213	1382	1750
56	586	680	782	889	1129	140	927	1076	1235	1407	1780
58	596	692	796	905	1149	145	944	1095	1257	1433	1812
60	607	704	810	920	1168	150	960	1114	1279	1456	1843

Assumed coefficient of discharge per cent. = .995 .995 .996 .997 .997

TABLE 13

THEORETICAL DISCHARGE THROUGH CIRCULAR OUTLETS

For Use in Making Hydrant Tests With Pitot Tubes

-10%

U. S. Gallons per minute

Head.		Velocity in Feet per Sec.	Diameter of Outlet in Inches.										
Lbs. per sq. in.	Feet.		2	2⅛	2¼	2⅜	2½	2⅝	2¾	2⅞	3	3⅛	3¼
1	2.31	12.20	119	134	151	168	187	205	226	246	269	292	315
2	4.62	17.25	169	191	214	238	264	291	319	348	380	413	446
3	6.93	21.13	207	233	262	291	323	356	391	425	465	505	546
4	9.24	24.39	239	269	302	336	373	410	452	492	537	584	631
5	11.54	27.26	267	302	338	380	417	460	505	553	601	652	705
6	13.85	29.87	292	330	370	413	457	504	553	605	658	714	772
7	16.16	32.26	316	358	400	445	494	545	597	653	711	772	834
8	18.47	34.49	338	382	427	475	528	581	638	696	760	824	892
9	20.78	36.58	358	405	453	505	560	615	677	740	806	874	946
10	23.09	38.56	378	426	478	532	590	649	714	780	850	923	997
11	25.40	40.45	396	446	501	558	619	680	749	817	891	968	1046
12	27.71	42.24	414	466	524	582	646	711	782	85	931	1010	1092
13	30.02	43.97	431	486	545	606	673	740	814	888	969	1051	1137
14	32.33	45.63	447	505	566	629	698	768	945	921	1005	1092	1180
15	34.63	47.22	463	523	586	652	722	795	874	953	1040	1130	1221
16	36.94	48.78	478	540	605	673	746	821	903	985	1075	1166	1261
17	39.25	50.28	493	556	623	694	769	847	931	1015	1108	1201	1300
18	41.56	51 73	507	572	642	714	791	872	958	1044	1140	1235	1338
19	43.87	53.15	521	588	659	234	813	896	904	1072	1171	1269	1374
20	46.18	54.54	534	603	676	754	834	920	1010	1100	1201	1302	1410
22	50.80	57.19	560	632	709	789	875	964	1059	1155	1260	1368	1479
24	55.41	59.74	585	660	741	823	914	1006	1106	1206	1316	1430	1545
26	60.03	62.18	609	687	771	857	951	1047	1151	1255	1370	1485	1608
28	64.65	64.52	632	714	800	890	987	1086	1194	1303	1422	1540	1668
30	69.27	66.79	654	740	828	920	1022	1124	1236	1350	1472	1594	1727
32	73.89	68.98	676	764	856	950	1055	1162	1277	1395	1520	1648	1784
34	78.50	71.10	697	787	882	980	1088	1199	1316	1438	1566	1701	1838
36	83.12	73.16	717	810	908	1010	1119	1234	1354	1479	1612	1752	1892
38	87.74	75.17	736	832	932	1038	1150	1267	1392	1520	1656	1800	1944
40	92.36	77.11	755	854	956	1065	1180	1300	1428	1559	1699	1848	1994
42	96.98	79.03	774	875	980	1090	1209	1331	1463	1596	1741	1892	2043
44	101.59	80.88	792	895	1003	1115	1237	1361	1497	1632	1782	1935	2091
46	106.21	82.70	810	915	1025	1140	1265	1391	1531	1670	1822	1975	2138
48	110.83	84.48	828	935	1047	1163	1293	1421	1564	1707	1861	2020	2184
50	115.45	86.22	845	954	1069	1186	1319	1450	1596	1742	1900	2060	2229
52	120.09	.....	861	....	1091	....	1343	....	1628	....	1937	....	2274
54	124.71	.....	878	....	1111	....	1372	....	1659	....	1974	....	2317
56	129.33	.....	894	....	1132	...	1400	....	1689	....	2010	....	2359
58	133.94	.....	909	....	1152	....	1424	....	1719	....	2046	....	2401
60	138.56	.....	925	....	1171	....	1448	....	1749	....	2081	....	2442
62	143.18	.....	941	....	1191	....	1472	....	1777	....	2115	....	2483
64	147.80	.....	956	....	1210	....	1496	....	1806	....	2149	....	2522
66	152.42	.....	971	....	1228	....	1516	....	1834	....	2183	....	2561
68	157.04	.....	985	....	1247	....	1540	....	1862	....	2215	....	2600
70	161.66	.....	999	....	1265	....	1564	....	1889	....	2248	....	2638
75	173.21	.....	1034	....	1310	....	1618	....	1955	....	2326	..	2730
80	184.75	.....	1068	....	1352	....	1672	....	2019	....	2403	....	2820
90	207.85	.....	1133	....	1434	....	1772	....	2142	....	2549	....	2991
100	230.94	.....	1194	....	1512	....	1857	....	2258	....	2687	....	3153

TABLE 13

THEORETICAL DISCHARGE THROUGH CIRCULAR OUTLETS

For Use in Making Hydrant Tests With Pitot Tubes

U. S. Gallons per minute

Diameter of Outlet in Inches.

3⅜	3½	3⅝	3¾	3⅞	4	4⅛	4¼	4⅜	4½	4⅝	4¾	4⅞	5
340	366	394	420	448	478	508	540	570	605	640	675	710	748
480	517	555	594	634	676	718	765	805	855	904	955	1005	1060
588	633	680	727	775	827	880	935	986	1044	1105	1165	1230	1295
680	731	785	840	895	955	1018	1080	1140	1207	1275	1350	1420	1492
760	817	878	938	1002	1068	1135	1210	1280	1352	1430	1510	1588	1676
835	896	962	1028	1098	1170	1245	1330	1400	1485	1570	1652	1740	1835
900	967	1040	1111	1185	1263	1345	1430	1510	1600	1690	1785	1880	1980
960	1034	1110	1187	1265	1351	1440	1528	1615	1710	1805	1910	2010	2115
1020	1097	1178	1259	1344	1433	1528	1620	1715	1818	1915	2025	2130	2245
1076	1156	1240	1327	1420	1510	1608	1710	1810	1920	2020	2135	2246	2370
1128	1213	1305	1392	1486	1584	1685	1794	1895	2010	2120	2240	2357	2485
1178	1267	1360	1454	1550	1655	1757	1870	1975	2095	2215	2340	2458	2595
1226	1318	1418	1515	1615	1722	1829	1950	2060	2180	2305	2435	2559	2700
1273	1368	1470	1572	1675	1787	1898	2020	2138	2260	2390	2525	2655	2800
1318	1416	1520	1626	1735	1849	1965	2089	2215	2340	2470	2610	2750	2900
1361	1463	1570	1679	1795	1910	2030	2158	2288	2418	2550	2695	2845	2990
1402	1508	1619	1731	1850	1969	2092	2226	2354	2492	2630	2780	2930	3080
1441	1551	1662	1781	1901	2026	2151	2290	2420	2564	2710	2865	3010	3170
1480	1594	1715	1830	1952	2082	2218	2352	2485	2635	2785	2945	3090	3260
1519	1635	1755	1877	2002	2136	2270	2412	2548	2700	2855	3015	3170	3340
1595	1715	1840	1969	2100	2240	2380	2538	2670	2838	2995	3160	3330	3505
1665	1791	1920	2056	2194	2340	2484	2642	2790	2960	3125	3300	3480	3660
1732	1864	2000	2140	2282	2435	2588	2758	2910	3080	3250	3440	3620	3815
1798	1935	2078	2221	2368	2527	2682	2854	3020	3200	3375	3565	3755	3960
1860	2003	2150	2299	2450	2616	2776	2960	3130	3310	3496	3690	3885	4100
1920	2069	2222	2375	2530	2702	2870	3055	3230	3420	3615	3820	4015	4235
1980	2132	2290	2448	2608	2785	2960	3150	3328	3522	3720	3940	4140	4370
2040	2194	2358	2519	2686	2866	3045	3240	3424	3622	3825	4050	4255	4495
2096	2254	2420	2588	2760	2944	3130	3330	3519	3720	3930	4155	4370	4610
2150	2313	2482	2655	2834	3021	3212	3418	3608	3818	4030	4270	4480	4730
2202	2370	2544	2721	2902	3095	3290	3500	3697	3911	4130	4375	4590	4845
2252	2426	2606	2785	2969	3168	3365	3580	3785	4004	4228	4475	4700	4960
2302	2480	2665	2847	3035	3239	3440	3660	3870	4097	4325	4575	4810	5075
2352	2533	2720	2908	3100	3309	3515	3740	3955	4185	4420	4675	4910	5180
2400	2586	2775	2968	3164	3377	3583	3818	4034	4268	4510	4770	5010	5280

Note: Unless the orifice is entirely filled with a stream containing no air, the figures may be misleading or worthless, and the pitot orifice should be in transparent or clear water free from air. The discharge will seldom be more than 80 or 90 per cent. of the figure given in the table unless the contraction or sectional area of the stream is taken into account.

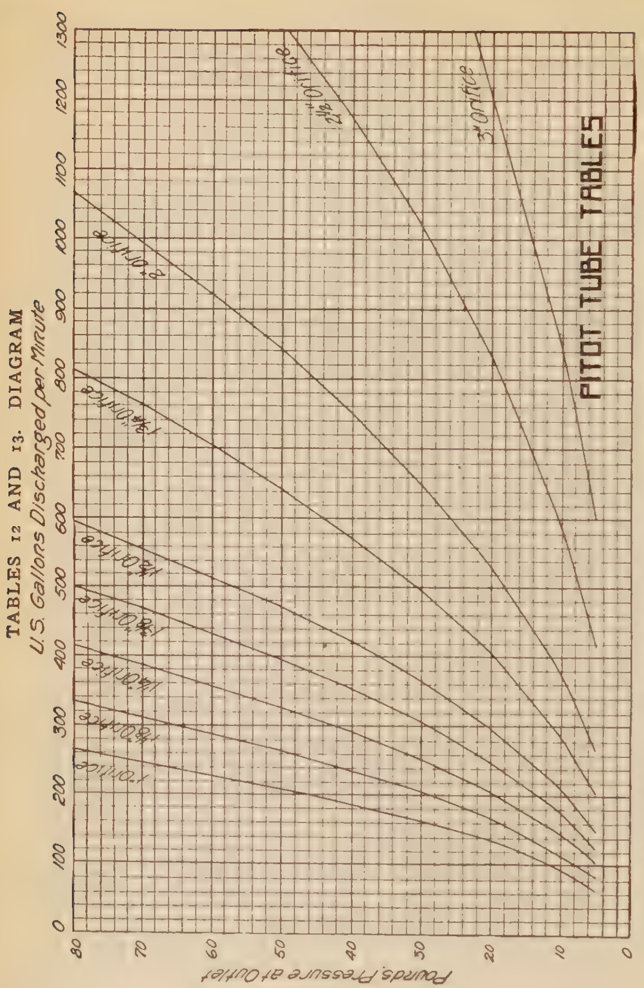


FIG. 165. THEORETICAL DISCHARGE THROUGH CIRCULAR ORIFICES.
(Extracts from Tables 12 and 13.)

—10%

TABLES 14 TO 17. DIAGRAM

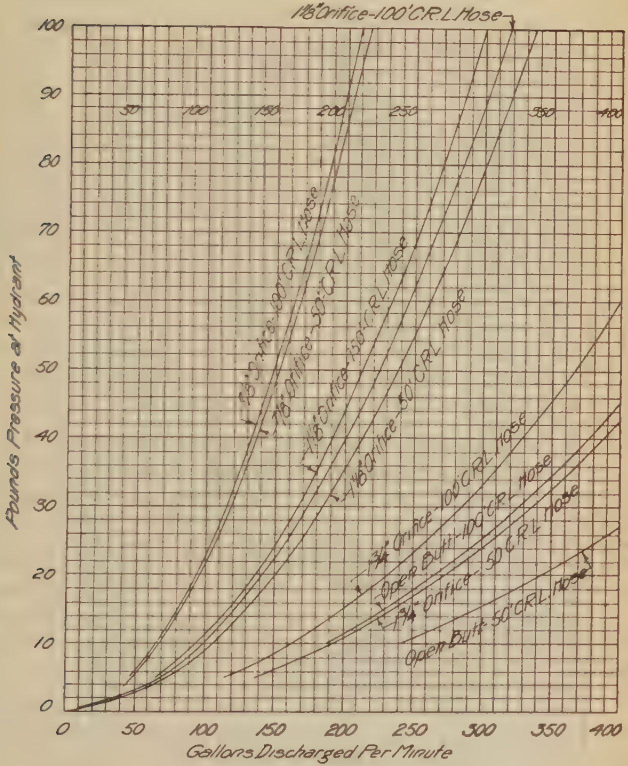


FIG. 166. HOSE STREAM DATA.
(Selected from Tables on pages 704–711 inclusive.)

TABLE 14

PUMP INSPECTION

Discharge of Nozzles attached

HYDRANT PRESSURE indicated while Stream is flowing by Gauge attached to Hydrant, as shown.	1⅜-Inch Smooth Nozzle. Gals. per Min.			1¼-Inch Smooth Nozzle. Gals. per Min.			1⅛-Inch Smooth Nozzle. Gals. per Min.			1-Inch Smooth Nozzle. Gals. per Min.			⅞-Inch Smooth Nozzle, or 1-inch Ring Nozzle. Gals. per Min.		
Lbs. per sq. in.	Unlined Linen Hose.	Inferior Rubber-lined Cotton "Mill Hose."—Inside Rough.	Ordinary best quality Rubber-lined Hose.—Inside Smooth.	Unlined Linen Hose.	Inferior Rubber-lined Cotton "Mill Hose."—Inside Rough.	Ordinary best quality Rubber-lined Hose.—Inside Smooth.	Unlined Linen Hose.	Inferior Rubber-lined Cotton "Mill Hose."—Inside Rough.	Ordinary best quality Rubber-lined Hose.—Inside Smooth.	Unlined Linen Hose.	Inferior Rubber-lined Cotton "Mill Hose."—Inside Rough.	Ordinary best quality Rubber-lined Hose.—Inside Smooth.	Unlined Linen Hose.	Inferior Rubber-lined Cotton "Mill Hose."—Inside Rough.	Ordinary best quality Rubber-lined Hose.—Inside Smooth.
5	90	92	103	80	82	90	70	71	75	59	59	62	47	47	48
10	127	131	146	114	116	127	99	101	107	83	84	87	66	67	68
15	155	160	179	140	143	154	121	123	131	101	102	106	81	81	84
20	180	185	206	161	164	179	140	142	151	117	118	123	93	94	96
25	201	207	230	180	184	200	156	158	169	131	132	137	104	105	107
30	220	226	251	197	202	219	171	173	184	143	144	150	114	115	118
35	238	245	272	213	218	236	184	188	199	154	156	162	123	124	127
40	255	262	291	227	233	253	197	201	213	165	167	173	132	133	136
45	270	278	309	241	247	269	209	213	226	175	177	184	140	141	144
50	284	293	325	255	260	283	221	224	238	184	186	194	147	148	152
55	298	307	341	267	273	296	232	235	250	193	195	204	154	155	159
60	311	320	357	279	285	309	242	245	261	202	204	213	161	162	167
65	324	333	371	290	296	322	252	255	272	210	213	221	168	169	173
70	336	346	385	301	307	334	261	265	281	218	221	230	174	176	180
75	348	358	399	311	318	344	270	275	291	226	228	238	181	182	186
80	359	370	412	322	329	357	279	284	301	233	236	246	186	188	192
85	371	382	425	332	339	369	288	293	310	240	243	253	192	193	198
90	381	393	437	341	349	379	296	301	319	247	250	261	197	199	204
95	392	403	449	350	358	390	304	309	328	253	257	268	203	204	209
100	402	414	461	359	368	400	312	317	337	260	264	275	208	210	215

Quantities are stated in United States gallons of 231 cubic inches.

TABLE 14

TABLES.

to 50 Feet of 2½-inch Hose.

TABLE B.—No. 1
(From experiments of J. R. FREEMAN, 1888.)

¾-Inch Smooth Nozzle, or ⅞-inch Ring Nozzle. Gals. per Min.			1⅜-Inch Ring Nozzle. Gals. per Min.			1¼-Inch Ring Nozzle. Gals. per Min.			1⅛-Inch Ring Nozzle. Gals. per Min.			HYDRANT PRESSURE.
Unlined Linen Hose.	Inferior Rubber-lined Cotton "Mill Hose."—Inside Rough.	Ordinary best quality Rubber-lined Hose.—Inside Smooth.	Unlined Linen Hose.	Inferior Rubber-lined Cotton "Mill Hose."—Inside Rough.	Ordinary best quality Rubber-lined Hose.—Inside Smooth.	Unlined Linen Hose.	Inferior Rubber-lined Cotton "Mill Hose."—Inside Rough.	Ordinary best quality Rubber-lined Hose.—Inside Smooth.	Unlined Linen Hose.	Inferior Rubber-lined Cotton "Mill Hose."—Inside Rough.	Ordinary best quality Rubber-lined Hose.—Inside Smooth.	Lbs. per sq. in.
36	36	37	75	76	84	66	67	70	56	56	59	5
50	50	51	108	110	118	94	96	101	80	81	84	10
61	61	62	132	135	144	115	117	124	98	99	103	15
71	71	72	152	155	167	133	135	143	113	114	119	20
79	80	81	170	174	187	149	151	159	126	128	133	25
86	87	88	187	191	205	163	165	175	138	140	145	30
93	93	95	201	206	221	176	179	189	149	151	157	35
100	100	101	215	219	237	188	191	202	159	162	168	40
106	106	108	229	233	251	200	203	214	169	172	178	45
112	112	113	241	245	264	211	214	226	179	181	188	50
117	117	119	253	257	277	221	224	237	187	189	197	55
122	122	124	264	269	289	231	234	247	196	198	205	60
127	127	129	275	280	301	240	244	257	205	206	214	65
132	132	134	285	291	313	249	253	267	212	213	222	70
137	137	139	295	301	324	258	262	276	219	221	230	75
141	142	144	305	311	334	266	270	285	226	228	237	80
145	146	148	314	320	345	274	279	294	233	235	244	85
149	150	152	323	329	355	282	287	303	239	242	252	90
153	154	156	332	338	364	290	295	311	246	249	259	95
158	159	161	340	347	374	298	303	319	253	255	266	100

Note—The above figures for Ring Nozzle Discharges will apply to any ordinary form of Ring accurately enough for practical purposes, but apply especially to ordinary form of Ring Nozzle with square shoulder 1/16 or ⅛ inch deep. Ring Nozzles with "under-cut" or "knife-edge" shoulder, discharge, as ordinarily constructed, about 3 per cent. less than quantity given above.

TABLE 15

PUMP INSPECTION

Discharge of Nozzles attached

HYDRANT PRESSURE indicated while Stream is flowing by Gauge attached to Hydrant, as shown.	1⅜-Inch Smooth Nozzle. Gals. per Min.			1¼-Inch Smooth Nozzle. Gals. per Min.			1⅛-Inch Smooth Nozzle. Gals. per Min.			1-Inch Smooth Nozzle. Gals. per Min.			⅞-Inch Smooth Nozzle, or 1-inch Ring Nozzle. Gals. per Min.		
Lbs. per sq. in.	Unlined Linen Hose.	Inferior Rubber-lined Cotton "Mill Hose."—Inside Rough.	Ordinary best quality Rubber-lined Hose.—Inside Smooth.	Unlined Linen Hose.	Inferior Rubber-lined Cotton "Mill Hose."—Inside Rough.	Ordinary best quality Rubber-lined Hose.—Inside Smooth.	Unlined Linen Hose.	Inferior Rubber-lined Cotton "Mill Hose."—Inside Rough.	Ordinary best quality Rubber-lined Hose.—Inside Smooth.	Unlined Linen Hose.	Inferior Rubber-lined Cotton "Mill Hose."—Inside Rough.	Ordinary best quality Rubber-lined Hose.—Inside Smooth.	Unlined Linen Hose.	Inferior Rubber-lined Cotton "Mill Hose."—Inside Rough.	Ordinary best quality Rubber-lined Hose.—Inside Smooth.
5	75	79	93	70	72	82	62	64	71	54	55	59	44	45	47
10	107	111	131	98	102	116	88	91	100	76	78	83	63	63	66
15	131	136	160	121	125	143	108	111	123	93	95	102	76	77	81
20	151	157	185	139	144	164	125	128	142	107	110	118	88	89	94
25	169	176	207	155	161	184	139	143	158	120	122	132	99	100	105
30	185	192	226	170	176	202	152	156	173	132	134	144	108	110	115
35	200	208	245	184	190	218	165	169	188	142	145	156	117	119	124
40	214	222	262	197	204	233	176	181	201	152	155	167	125	127	133
45	226	236	278	209	216	247	187	192	213	161	165	177	132	134	141
50	239	249	293	220	228	260	197	202	224	170	174	186	139	142	148
55	251	261	307	231	239	273	207	212	235	178	182	195	146	148	155
60	261	273	320	241	250	285	216	222	245	186	190	204	153	155	162
65	272	284	333	251	260	296	225	231	255	194	198	213	159	161	169
70	282	294	346	261	270	307	233	240	265	201	205	221	165	167	176
75	292	304	358	270	279	319	241	248	275	208	212	228	171	173	182
80	301	314	370	278	288	329	249	256	284	215	219	236	177	179	188
85	311	324	382	287	297	339	257	264	293	222	226	243	182	185	193
90	320	333	393	295	306	349	264	272	301	228	233	250	188	190	199
95	329	342	403	303	314	358	272	279	309	234	239	257	192	195	204
100	337	351	414	311	322	368	279	287	317	240	245	264	197	200	210

Quantities are stated in United States gallons of 231 cubic inches.

TABLE 15

TABLES.

to 100 Feet of 2½-inch Hose.

TABLE B.—No. 2.
(From experiments of J. R. FREEMAN, 1888.)

¾-Inch Smooth Nozzle, or ⅞-inch Ring Nozzle. Gals. per Min.			1⅜-Inch Ring Nozzle. Gals. per Min.			1¼-Inch Ring Nozzle. Gals. per Min.			1⅛-Inch Ring Nozzle. Gals. per Min.			HYDRANT PRESSURE.
Unlined Linen Hose.	Inferior Rubber-lined Cotton "Mill Hose."—Inside Rough.	Ordinary best quality Rubber-lined Hose.—Inside Smooth.	Unlined Linen Hose.	Inferior Rubber-lined Cotton "Mill Hose."—Inside Rough.	Ordinary best quality Rubber-lined Hose.—Inside Smooth.	Unlined Linen Hose.	Inferior Rubber-lined Cotton "Mill Hose."—Inside Rough.	Ordinary best quality Rubber-lined Hose.—Inside Smooth.	Unlined Linen Hose.	Inferior Rubber-lined Cotton "Mill Hose."—Inside Rough.	Ordinary best quality Rubber-lined Hose.—Inside Smooth.	Lbs. per sq. in.
34	34	35	67	69	78	60	62	68	52	53	57	5
48	49	50	94	97	110	85	87	96	74	75	81	10
59	60	61	115	120	135	104	107	117	90	92	99	15
68	69	71	133	138	155	120	123	135	105	107	114	20
76	77	79	149	154	174	134	138	151	117	119	128	25
84	84	87	163	169	191	147	151	165	128	130	140	30
90	91	93	176	182	206	159	163	179	139	141	151	35
97	97	100	188	195	219	169	174	191	148	151	162	40
103	103	106	200	207	233	180	185	203	157	160	172	45
108	109	112	211	218	245	190	195	214	165	169	181	50
113	114	117	221	229	257	199	204	224	173	177	189	55
118	119	122	231	239	269	208	213	234	181	185	198	60
123	124	127	241	248	280	217	222	244	189	192	206	65
128	129	132	250	258	291	225	230	253	195	199	213	70
132	133	137	259	267	301	233	239	262	203	206	221	75
137	138	142	267	275	311	240	246	270	209	213	228	80
141	142	146	275	284	320	247	254	279	215	219	235	85
145	146	150	283	292	329	255	261	287	222	226	242	90
149	150	154	291	300	338	262	269	295	228	232	249	95
153	154	158	299	308	347	269	275	302	234	238	255	100

Note—The above figures for Ring Nozzle Discharges will apply to any ordinary form of Ring accurately enough for practical purposes, but apply especially to ordinary form of Ring Nozzle with square shoulder 1/16 or ⅛ inch deep. Ring Nozzles with "under-cut" or "knife-edge" shoulder, discharge, as ordinarily constructed, about 3 per cent. less than quantity given above.

TABLE 16

PUMP INSPECTION

Discharge of Nozzles attached t

HYDRANT PRESSURE. Indicated while Stream is flowing by Gauge attached to Hydrant as shown.	50 Feet 2½-Inch Hose.						100 Feet 2½-Inch Hose.					
	1¾-Inch Smooth Nozzle. Gals. per Min.			1½-Inch Smooth Nozzle. Gals. per Min.			1¾-Inch Smooth Nozzle. Gals. per Min.			1½-Inch Smooth Nozzle. Gals. per Min.		
Lbs. per sq. in.	Unlined Linen Hose.	Inferior Rubber-lined Cotton "Mill Hose."—Inside Rough.	Ordinary best quality Rubber-lined Hose.—Inside Smooth.	Unlined Linen Hose.	Inferior Rubber-lined Cotton "Mill Hose."—Inside Rough.	Ordinary best quality Rubber-lined Hose.—Inside Smooth.	Unlined Linen Hose.	Inferior Rubber-lined Cotton "Mill Hose."—Inside Rough.	Ordinary best quality Rubber-lined Hose.—Inside Smooth.	Unlined Linen Hose.	Inferior Rubber-lined Cotton "Mill Hose."—Inside Rough.	Ordinary best quality Rubber-
5	110	114	136	97	101	115	86	90	114	80	83	10
10	154	162	193	138	143	163	122	128	162	113	118	14
15	190	198	237	169	176	200	150	157	198	138	145	17
20	219	229	274	196	203	232	173	182	229	160	167	20
25	245	256	306	219	227	259	193	203	256	179	187	22
30	268	281	335	239	248	283	211	222	281	196	205	24
35	290	303	362	259	268	306	228	240	303	212	222	26
40	310	324	387	277	286	327	244	256	324	226	237	28
45	328	344	410	294	304	347	258	272	344	240	251	30
50	346	363	432	310	321	366	272	287	363	253	265	32
55	364	380	453	325	336	383	285	301	380	265	278	33
60	380	397	473	339	350	400	298	314	397	277	290	35
65	395	414	492	353	364	417	310	327	414	288	302	36
70	410	429	510	366	378	432	321	339	429	299	313	37
75	425	444	528	379	392	447	331	351	444	309	324	39
80	439	458	546	391	405	461	344	363	458	319	335	40
85	452	472	563	403	417	476	354	374	472	329	346	41
90	465	487	579	415	429	490	364	385	487	339	356	42
95	477	500	595	427	441	503	374	396	500	348	366	44
100	489	512	610	438	453	515	383	406	512	357	375	45

Note—This table was computed from formulas (2) and (7) of Appendix, "Fr man on Hydraulics of Fire Streams," in Trans. Am. Soc. C. E., Nov. 1889. Co cient of discharge used = .974.

For **Underwriter Playpipe with Tip Removed** (this outlet should be 1⅜ inch use columns for 1½-inch Smooth Nozzle.

TABLES.

various lengths of 2½-inch hose.

TABLE B.—No. 2A.

(From experiments of J. R. FREEMAN, 1888. Computed, 1900.)

150 Feet 2½-Inch Hose.

1⅜-Inch Smooth Nozzle. Gals. per Min.			1¼-Inch Smooth Nozzle. Gals. per Min.			1⅛-Inch Smooth Nozzle. Gals. per Min.			1-Inch Smooth Nozzle. Gals. per Min.			HYDRANT PRESSURE indicated while Stream is flowing by Gauge attached to Hydrant, as shown.
Unlined Linen Hose.	Inferior Rubber-lined Cotton "Mill-Hose."—Inside Rough.	Ordinary best quality Rubber-lined Hose.—Inside Smooth.	Unlined Linen Hose.	Inferior Rubber-lined Cotton "Mill Hose."—Inside Rough.	Ordinary best quality Rubber-lined Hose.—Inside Smooth.	Unlined Linen Hose.	Inferior Rubber-lined Cotton "Mill Hose."—Inside Rough.	Ordinary best quality Rubber-lined Hose.—Inside Smooth.	Unlined Linen Hose.	Inferior Rubber-lined Cotton "Mill Hose."—Inside Rough.	O-dinary best quality Rubber-lined Hose.—Ins.de Smooth.	Lbs. per sq. in.
					80	56	60	67	45	50	56	5
81	91	118	88	91	110	81	84	94	69	73	79	10
107	117	146	108	112	134	97	101	119	86	90	99	15
130	138	168	123	128	155	113	118	136	100	103	114	20
147	154	189	139	145	171	127	131	152	112	116	127	25
163	170	207	153	159	187	140	144	165	122	126	139	30
179	184	225	163	171	203	150	155	178	132	136	151	35
190	196	239	174	183	216	160	166	190	141	145	161	40
200	208	254	185	194	229	170	176	201	150	154	171	45
210	220	267	195	205	241	179	186	212	158	163	180	50
220	230	279	205	215	253	188	195	223	166	172	189	55
229	241	292	215	225	265	197	204	233	174	179	198	60
238	251	305	224	234	277	205	212	243	181	186	206	65
248	260	317	232	243	287	213	220	252	187	192	213	70
257	269	328	240	251	297	220	228	261	194	199	221	75
265	277	338	248	259	306	228	235	269	200	205	228	80
273	285	348	256	267	316	235	243	277	207	212	234	85
281	294	358	264	275	325	242	250	285	212	218	241	90
288	302	368	271	283	334	248	257	293	218	224	247	95
295	310	378	278	290	342	255	263	300	223	230	253	100

Quantities are stated in United States gallons of 231 cubic inches.

TABLE 17

(If Gauge is not connected in this manner, proper allowance must be made for loss of pressure between Gauge and Hydrant.)

PUMP INSPECTION

The degree of accuracy attained in estimating of the two preceding tables — B, No. 1 and

HYDRANT PRESSURE	Quantity of Water Discharged per minute through ordinary 2½-inch Fire Hose, (United States Gallons of 231 cubic inches.) Open Hose Butt. No Play-								
	Length 25 feet.			Length 50 feet.			Length 100 feet.		
Indicated while Stream is flowing by Gauge attached to Hydrant, as shown. Lbs. per sq. in.	Unlined Linen Hose.	Inferior Rubber-lined Cotton "Mill Hose." Inside Rough.	Ordinary best quality Rubber-lined Hose. Inside Smooth.	Unlined Linen Hose.	Inferior Rubber-lined Cotton "Mill Hose." Inside Rough.	Ordinary best quality Rubber-lined Hose. Inside Smooth.	Unlined Linen Hose.	Inferior Rubber-lined Cotton "Mill Hose." Inside Rough.	Ordinary best quality Rubber-lined Hose. Inside Smooth.
10	231	242	297	176	188	242	132	140	188
15	283	297	363	217	230	297	161	171	230
20	326	343	419	251	266	343	186	199	266
25	365	383	468	281	297	383	208	222	297
30	400	420	514	307	326	420	228	243	326
35	432	453	554	332	352	453	246	262	352
40	462	484	593	355	376	484	264	280	376
45	490	514	630	377	399	514	280	297	399
50	516	542	664	398	420	542	294	313	420
55	541	568	696	416	440	568	308	328	440
60	565	594	726	434	460	594	322	343	460
65	588	618	756	452	480	618	336	358	480
70	610	641	784	470	498	641	348	371	498
75	632	663	812	486	515	663	360	384	515
80	652	685	....	502	532	685	372	397	532
85	672	706	....	518	548	706	383	409	548
90	692	727	....	533	564	727	394	421	564
95	712	747	....	547	579	747	405	432	579
100	730	766	....	561	594	766	416	443	594
110	766	806	....	588	623	806	436	465	623
120	800	....	....	614	651	....	456	486	651
	If Hydrant were of Style A, discharge would be 5 per cent. greater.	If Hydrant were of Style A, discharge would be 5 per cent. greater.	If Hydrant were of Style A, discharge would be 9 per cent. greater.	If Hydrant were of Style A, discharge would be 3 per cent. greater.	If Hydrant were of Style A, discharge would be [illegible] per cent. greater.	If Hydrant were of Style A, discharge would be 6 per cent. greater.	If Hydrant were of Style A, discharge would be 1½ per cent. greater.		

TABLE 17

TABLES.—"Open Hose Butts."

TABLE B.—No. 3.
(From experiments of J. R. FREEMAN, 1888.)

discharge through "Open Butt" is not nearly so great as may be obtained by the methods B. No. 2—by reason of greater influence of form of Hydrant and differences in Hose.

with Couplings of 2½-inch Bore. Pipe or Nozzle attached.

Length 200 feet.		Length 400 feet.	
Inferior Rubber-lined Cotton "Mill Hose." Inside Rough.	Ordinary best quality Rubber-lined Hose. Inside Smooth.	Inferior Rubber-lined Cotton "Mill Hose." Inside Rough.	Ordinary best quality Rubber-lined Hose. Inside Smooth.
102	140	74	102
125	171	90	125
144	199	104	144
161	222	116	161
177	243	127	177
190	262	137	190
204	280	146	204
217	297	155	217
228	313	164	228
239	328	172	239
250	343	179	250
260	358	186	260
270	371	194	270
279	384	201	279
288	397	208	288
297	409	215	297
306	421	221	306
314	432	227	314
322	443	232	322
338	465	243	338
354	486	254	354

NOTE.—The values in this table are based on experiments with these kinds of Hose attached to a Chapman 4-way Independent Gate Hydrant (Coeff. Disch. by Expt. 0.71). So far as influence of kind of Hydrant upon discharge is concerned, the same values are correct enough for practical purposes, except as noted in margin of columns.

It will be noted that this table gives, for each length, the discharge through the best or smoothest hose, and gives, also, discharge for same length of Hose with roughest waterway. By use of a little judgment in interpolating between these two values, error, in ordinary use of table need not exceed 10 per cent.

(Style A.) Ordinary Matthews (R. D. Wood & Co.'s) Hydrant without independent gates, inside corner being rounded off.

◆

HOLYOKE HYDRANT TESTS.

Tables B, No. 4 and B, No. 5 for the discharge of open hydrant butts, and the values following, on the friction losses in hydrants (pages 58 and 59), were obtained from the Holyoke Hydrant Tests.

These tests were made in 1897 and 1898, for the Water Department of Holyoke, by Charles L. Newcomb, M. E., the Inspection Department of the Associated Factory Mutual Insurance Cos. co-operating in the work and in the computation of results. For full data on these experiments, see "Transactions of the American Society of Mechanical Engineers," vol. xx.

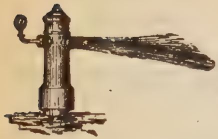
TABLE 18

(If Gauge is not connected in this manner, proper allowance must be made for loss of pressure between Gauge and Hydrant.)

PUMP INSPECTION

Discharge through One Open

Diameter of Outlet



If the diameter of outlet is not exactly 2½ inches, an additional correction as follows must be made.

Diameter.	Add.	Deduct.
2⅝	10 per cent.	....
2 9/16	5 "	....
2 7/16	....	5 per cent.
2⅜	....	10 "
2¼	....	19 "

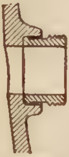
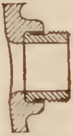
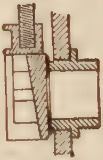
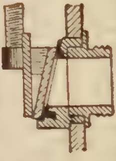
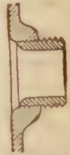
HYDRANT PRESSURE indicated while Stream is flowing by Gauge attached to Hydrant, as shown.	Chapman 2-Way.	Chapman 2-Way.	Chapman 2-Way.	Chapman 3-Way.	Chapman 3 or 4-Way.	Coffin 2-Way.
	"No. 1." Old pattern made from 1878–1899. Casting at outlets, square and jagged. Inside diam. of bbl. at outlets, 4⅝ ins. 	"No. 2." Same Hydrant as No. 1, but with outlets chipped and filed fairly smooth and rounding, but with short radius.	"No. 3." 2-Way with Steamer Connection. Pattern made after 1898. Casting at outlets smooth and well rounded. Inside diam. of bbl. at outlets, 7¾ ins.  Use same values when no Steamer Connection.	Hexagonal Pattern, with Independent Gates, made after 1897. Outlets have sharp corners and project into bbl. Inside diam. of bbl. at outlets hex'l), 6 9/16 ins  Use same values for Ludlow 3, 4 and 6-Way.	Regular pattern of Independent Gate; also used as 3-Way, with one outlet blanked. Made since 1883. Outlets have sharp corners and project into bbl. Inside diam. of bbl. at outlets, 8¼ ins. 	Same discharge for 2-Way Gate & 2-Way Compression with Steamer Connection. Nozzle entrances have well rounded corners. Inside diam. of bbl. at outlets, 6 ins 
Lbs. per sq. in.	Gals. per Min.	Gals. per Min.	Gals. per Min.	Gals. per Min.	Gals. per Min.	Gals per Min.
10	440	547	552	371	363	499
15	541	667	678	458	444	610
20	627	765	776	531	513	705
25	700	853	861	593	573	785
30	762	938	928	648	630	855
35	820	1,018	986	701	680	919
40	878	1,090	1,035	748	725	980
45	929	1,155	1,084	792	767	1,039
50	979	1,218	1,133	835	806	1,093
55	1,025	1,280	1,182	877	845	1,144
60	1,070	1,337	1,227	915	883	1,193
65	1,112	1,394	1,269	951	919	1,240
70	1,154	1,447	1,309	987	953	1,285
75	1,195	1,499	1,349	1,021	986	1,329
80	1,234	1,549	1,385	1,055	1,018	1,370
85	1,270	1,598	1,420	1,087	1,049	1,410
90	1,305	1,644	1,454	1,119	1,080	1,450
95	1,342	1,690	1,489	1,148	1,109	1,490
100	1,375	1,734	1,520	1,177	1,138	1,528

TABLE 18

TABLES.—"Open Hydrant Butts"

TABLE B.—No. 4.

(From Holyoke Hydrant Tests by Chas. L. Newcomb, M. E.)

Hydrant Butt, without Hose attached exactly 2½ ins.

The degree of accuracy attained in estimating the discharge through the "open butt" is not nearly so great as may be obtained by the methods of the three preceding tables,—B, Nos. 1, 2, and 2A. Slight peculiarities in the construction of the nozzle, and possibly also in the shape of the hydrant head, make large differences in the discharge from the open butt without hose. The data below covers the types of outlets usually found and, with good judgment in applying corrections for hydrants not exactly coming under any of the cases given, results accurate within 10 to 15 per cent. may generally be obtained.

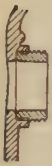
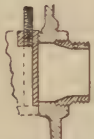
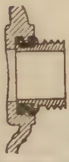
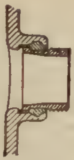
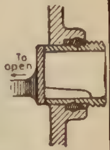
Holyoke 2-Way.	Holyoke 6-Way.	Ludlow 2-Way.	Mathews 2-Way.	Mathews 4-Way.	
Regular Pattern Gate or Compression. Casting at outlets well rounded but rough with nubs and projections. Average of 4 Hydrants.	Independent Gates. Outlets have sharp corners. Diam. of outlet hole in casting, 3¼ ins. Nipple tapers to 2½ ins. Inside diam. of bbl. at outlets 9¼ ins. Use same values for 3 and 4 Ways.	Regular Patt'rn. Diam. of outlet hole in casting, 2¾ to 3 ins. and square & jagged. Corners of 2½-in. nipple are sharp. Inside diam. of bbl. at outlets, 7⅝ ins.	2-Way with Steamer Connection. Casting rounded at outlets to radius of abt. ¼ in. Inside diam. of bbl. at outlets, 7½ ins. Use same values when no Steamer Connection.	Independent Gates. When open, distance from valve face to outlet is 1½ to 1⅝ in. Outlets have sharp corners. Inside diam. of bbl. at outlets, 8½ ins.	HYDRANT PRESSURE indicated while Stream is flowing by Gauge attached to Hydrant as shown.
					
Gals. per Min.	Gals. per Min.	Gals. per Min.	Gals. per Min.	Gals. per Min.	Lbs. per sq. in.
506	473	533	576	465	10
620	579	653	712	565	15
713	668	752	815	633	20
794	743	836	903	683	25
867	805	912	984	724	30
935	860	982	1,060	762	35
999	908	1,049	1,130	796	40
1,062	954	1,109	1,197	827	45
1,118	999	1,169	1,257	858	50
1,170	1,044	1,223	1,314	889	55
1,221	1,089	1,276	1,370	919	60
1,270	1,129	1,328	1,423	944	65
1,318	1,168	1,376	1,474	969	70
1,363	1,204	1,421	1,524	994	75
1,408	1,240	1,467	1,572	1,015	80
1,449	1,275	1,510	1,619	1,037	85
1,490	1,309	1,553	1,663	1,058	90
1,530	1,340	1,595	1,705	1,079	95
1,569	1,370	1,638	1,747	1,098	100

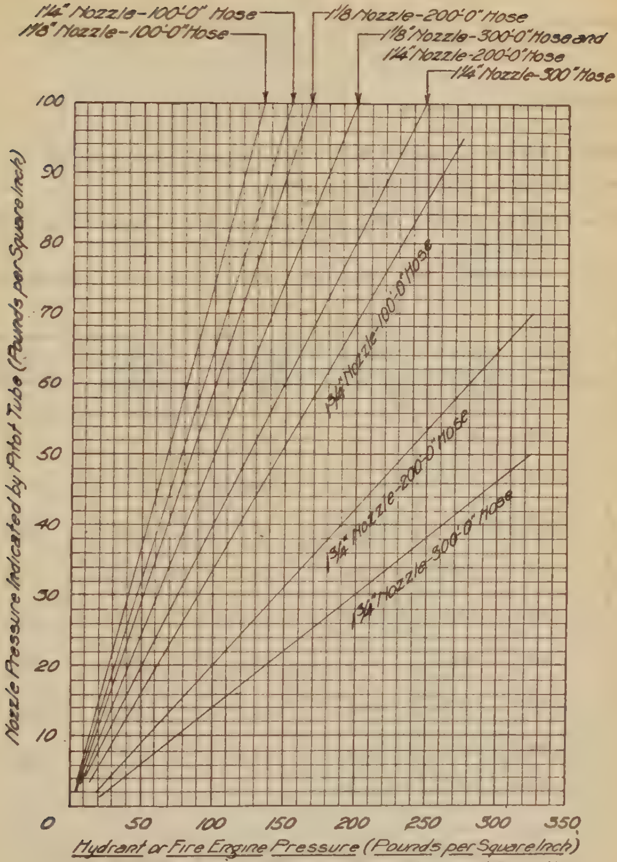
TABLE 19

HOSE STREAM TABLES—ENGINE TESTS

Nozzle Pressure Indicated by Pitot Tube.	Pressures Required at Hydrant or Fire Engine, While Stream is Flowing, to Maintain Nozzle Pressure Given in First Column, Through Various Lengths of Best Quality Rubber Lined Hose.											
	1⅛" Smooth Nozzle.				1¼" Smooth Nozzle.				1¾" Smooth Nozzle.			
	Gals. Dischg'd per Minute.	Length of Hose.			Gals. Dischg'd per Minute.	Length of Hose.			Gals. Dischg'd per Minute.	Length of Hose.		
		100'.	200'.	300'.		100'.	200'.	300'.		100'.	200'.	300'.
20	167	28	35	42	206	32	42	53	407	63	100	138
30	205	42	52	63	253	48	63	79	498	91	145	199
40	237	55	69	83	292	63	83	104	575	120	191	262
50	265	69	86	103	326	78	103	128	643	150	237	325
60	290	83	103	123	357	93	123	152	704	177	280	
70	313	96	119	142	386	108	142	176	761	206	325	
80	335	110	136	162	413	124	163	201	813	234		
90	355	123	152	181	438	139	182	225	862	261		
100	374	136	168	201	461	153	201	248	909			

Data from "Fire Engine Tests and Fire Stream Tables" by the National Board of Fire Underwriters.

TABLE 19. DIAGRAM



NOTE–Best quality Rubber Lined Hose and Smooth Nozzles used in the above Tests

Hydrant or Fire Engine Pressures Required to Deliver Water at Nozzle Pressures Given at Left Side of Plot

FIG. 167. HOSE STREAM TABLES—ENGINE TESTS

(Extracts from "Fire Engine Tests and Fire Stream Tables" by the National Board of Fire Underwriters)

TABLE 20

FORMULA FOR OBTAINING APPROXIMATE NOZZLE OR ENGINE PRESSURES, LENGTH OF LINE AND SIZE OF NOZZLE BEING GIVEN

$$\text{Nozzle Pressure in pounds} = \frac{\text{Engine Pressure}}{1.1 + K\,L}$$

Engine Pressure in pounds $=$ Nozzle Pressure $(1.1 + K\,L)$.

L = Number of 50-foot lengths of hose.

K = Constant, varying with size of nozzle and hose. See Table following.

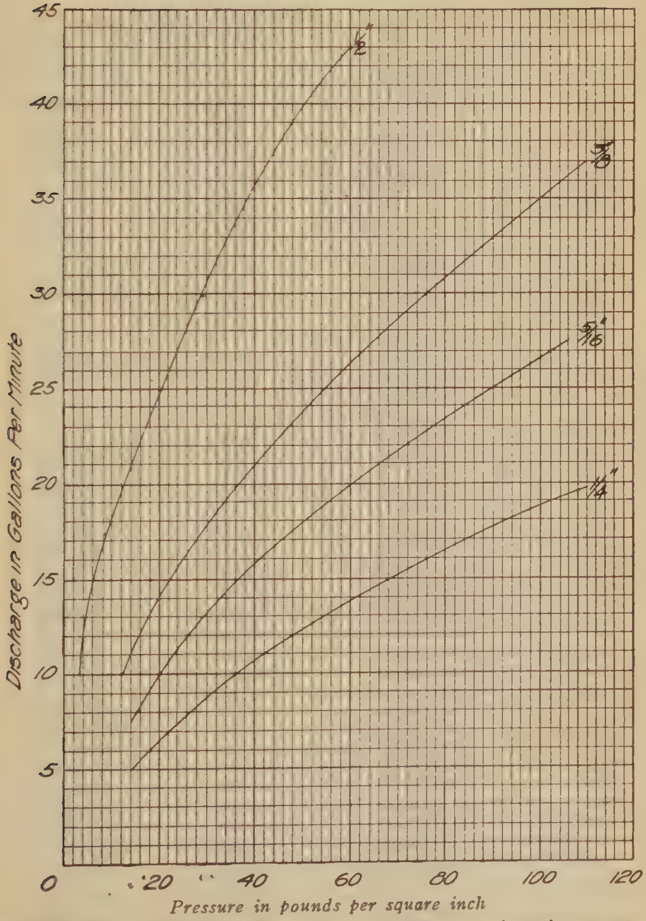
Size Nozzle, Inches.	K FOR					
	Single Line 2½" Hose.	Single Line 3" Hose.	Single Line 3½" Hose.	Two 2½" Lines Siamesed. *	Two 3" Lines Siamesed. *	3 Lines 2½" Hose. *
1	.105	.038	....	.025	....	....
1⅛	.167	.062	....	.043	....	....
1¼	.248	.092	.039	.066	.023	.028
1⅜	.341	.137	.059	.096	.034	.043
1½	.505	.192	.084	.135	.051	.061
1⅝	.680	.266	.113	.184	.068	.084
1¾	.907	.351	.152	.242	.093	.115
2	1.550	.605	.250	.418	.157	.190

* Allowance is made for loss in deluge set; these values will also give approximately correct figures for turret nozzles and water tower, except that in the latter, pressure equal to 0.434 times the height of tower must be subtracted from the engine pressure, before solving for nozzle pressure.

Data from "Fire Engine Tests and Fire Stream Tables" by the National Board of Fire Underwriters.

TABLE 21

DISCHARGE FROM SPRINKLERS



½″ orifice is standard for automatic sprinkler heads; other sizes are used for open sprinklers

FIG. 168. DISCHARGE FROM SPRINKLERS
(Averages of Tests by Underwriters' Laboratories)

TABLE 22

CAPACITIES OF VERTICAL CYLINDRICAL TANKS AND OF HEMISPHERICAL TANK BOTTOMS

Diameter in Feet.	Area in Sq. Feet.	Gallons per Vertical Feet of Cylinder.	Gallons in Hemispherical Bottom.
10	78.54	587.5	1,958
11	95.03	711	2,607
12	113.10	846	3,385
13	137.70	993	4,303
14	153.90	1,152	5,374
15	176.70	1,322	6,610
16	201.10	1,504	8,022
17	227.00	1,698	9,621
18	254.50	1,904	11,422
19	283.50	2,121	13,432
20	314.10	2,350	15,667
21	346.40	2,591	18,137
22	380.01	2,844	20,853
23	415.50	3,108	23,828
24	452.40	3,384	27,073
25	490.90	3,672	30,600
26	530.90	3,972	34,421
27	572.60	4,283	38,547
28	615.80	4,606	42,991
29	660.50	4,941	47,763
30	706.90	5,288	52,877
31	754.80	5,646	58,342
32	804.30	6,016	64,170
33	855.30	6,398	70,378
34	907.90	6,792	76,976
35	962.10	7,197	83,965
36	1,018.00	7,614	91,368
37	1,075.00	8,043	99,197
38	1,134.00	8,484	107,464
39	1,194.00	8,936	116,168
40	1,257.00	9,400	125,333
41	1,320.00	9,876	134,972
42	1,385.00	10,364	145,096
43	1,452.00	10,863	155,703
44	1,518.00	11,374	166,819
45	1,590.00	11,897	178,455
46	1,662.00	12,432	190,624
47	1,735.00	12,978	203,322
48	1,810.00	13,536	216,576
49	1,885.00	14,106	230,398
50	1,964.00	14,688	244,800

From Rules and Requirements on Gravity and Pressure Tanks of National Fire Protection Association.

TABLE 23

TYPICAL DIMENSIONS OF HEMISPHERICAL BOTTOMED TANKS OF STANDARD SIZES

Capacity in Gallons.			Size in Feet and Inches.	
Rated or Approximate Net.	Actual Net.	Total.	Diameter.	Height.
30,000	30,036	30,516	15–0	18–1
40,000	40,045	40,610	17–0	18–3
50,000	50,004	50,613	18–0	20–7
60,000	60,148	60,800	19–0	22–4
75,000	75,089	75,788	20–0	25–7
100,000	100,166	100,959	22–0	28–2
150,000	150,223	151,164	25–0	32–10

The height given is that of the cylindrical portion.
From Rules and Requirements on Gravity and Pressure Tanks of National Fire Protection Association.

TABLE 24

TYPICAL DIMENSIONS OF HORIZONTAL PRESSURE TANKS OF STANDARD SIZES

Approx. Gross. Cap. in Gals.	Approx. Net Cap. ⅔ Full.	Inside Diam. in Inches.	Inside Length in Feet.	Approx. Wt. of Water in Lbs. ⅔ Full.
3,000	2,000	60	20.2	16,670
3,000	2,000	66	17.0	16,670
3,000	2,000	72	14.2	16,670
4,500	3,000	66	25.4	25,000
4,500	3,000	72	21.3	25,000
4,500	3,000	78	18.2	25,000
6,000	4,000	72	28.2	33,340
6,000	4,000	78	24.2	33,340
6,000	4,000	84	21.0	33,340
7,500	5,000	78	30.3	41,670
7,500	5,000	84	26.2	41,670
7,500	5,000	90	22.7	41,670
9,000	6,000	84	31.4	50,000
9,000	6,000	90	27.3	50,000
9,000	6,000	96	24.0	50,000

Note—4,500 gals. gross capacity is the minimum ordinarily accepted for pressure tanks for automatic sprinkler systems.

In the above table the length of the tank has been figured as though the ends were plane instead of dished. The actual length of tanks of the above capacities and diameters will therefore be a trifle greater. See also Table 26.

TABLE 25

TYPICAL DIMENSIONS OF FLAT-BOTTOMED TANKS OF STANDARD SIZES

Approximate Net Capacity in Gallons.	Outside Dimensions.		Wooden Weight of Tank in Pounds.	Weight of Water in Tons.
	Average Diameter.	Length of Staves.		
5,000	10′–2″	10′–0″	2,500	20
10,000	13 –4	12 –0	4,000	40
15,000	14 –6	14 –0	5,300	68
20,000	15 –6	16 –0	6,500	80
25,000	17 –6	16 –0	7,600	100
30,000	18 –0	18 –0		120
50,000	22 –0	20 –0		200
75,000	24 –6	24 –0		300
100,000	28 –6	24 –0		400

Note—Other dimensions which provide the full net capacities are equally acceptable.

TABLE 26

CAPACITIES OF HORIZONTAL PRESSURE TANKS

Tanks Two-Thirds Full

Diameter Tank in Inches.	Height from Bottom in Inches.	Height Above Center in Inches.	Gallons Capacity per Foot of Length.	Diameter Tank in Inches.	Height from Bottom in Inches.	Height Above Center in Inches.	Gallons Capacity per Foot of Length
66	41¾	8¾	118	82	51¾	10¾	182
67	42¼	8¾	122	83	52½	11	187
68	43	9	126	84	53	11	191
69	43¾	9¼	129	85	53¾	11¼	196
70	44¼	9¼	133	86	54½	11½	201
71	45	9½	137	87	55	11½	205
72	45½	9½	141	88	55¾	11¾	210
73	46¼	9¾	145	89	56¼	11¾	215
74	46¾	9¾	149	90	57	12	220
75	47½	10	153	91	57½	12	225
76	48	10	157	92	58¼	12¼	230
77	48¾	10¼	161	93	58¾	12¼	235
78	49¼	10¼	165	94	59½	12½	240
79	50	10½	169	95	60	12½	245
80	50½	10½	174	96	60¾	12¾	250
81	51¼	10¾	178				

Note: See also Table 24

TABLE 27

RELATION IN HORIZONTAL PRESSURE TANKS OF HEIGHT OF WATER AND PRESSURE

Relation between height of water and pressure, starting with normal conditions of two-thirds full and 75 pounds air pressure.

Total capacity of tank = square of the radius in inches, times length in feet, times 0.1632 gallons.

Height of Water in Tank. Rds.—Radius.	Volume of Water. V—Total Capacity.	Pressure in Pounds Per Square Inch.
1.27 R	2–3 V	75 lbs. ✓
1.16 R	9–15 V	60 lbs.
1.05 R	8–15 V	49 lbs.
.95 R	7–15 V	41 lbs.
.84 R	6–15 V	35 lbs.
.73 R	1–3 V	30 lbs.
.62 R	4–15 V	26 lbs.
.50 R	1–5 V	22.5 lbs.
.38 R	2–15 V	19.5 lbs.
.24 R	1–15 V	17 lbs.
0 R	0	15 lbs.

TABLE 28

CAPACITIES OF RESERVOIRS

Capacity	Rectangular	Circular
60,000 gals.	15 ft. × 60 ft. × 10 ft.	33 ft. Diam. × 10 ft.
120,000 gals.	15 ft. × 120 ft. × 10 ft.	46 ft. Diam. × 10 ft.
180,000 gals.	15 ft. × 180 ft. × 10 ft.	56 ft. Diam. × 10 ft.
240,000 gals.	15 ft. × 240 ft. × 10 ft.	64 ft. Diam. × 10 ft.

Note: From these dimensions with uniform depth of 10 ft. other proportions and sizes for other capacities can readily be established. Reservoir depths must take into account limits of pump lifts.

From Rules and Regulations on Gravity and Pressure Tanks of National Fire Protection Association.

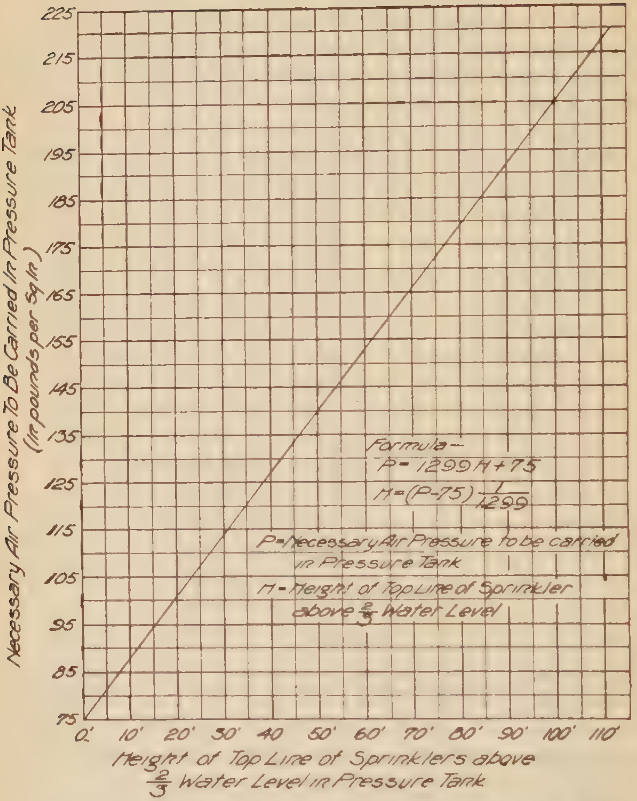


FIG. 169. NECESSARY EXCESS PRESSURE FOR PRESSURE TANKS

Note: As an example of the use of this diagram, consider the total air pressure to be carried where top line of sprinklers is 50 ft. above water line in pressure tank. Follow 50′ line vertically to diagonal line and read corresponding pressure at the left-hand side, viz., 140 lbs. or 65 lbs. above the 75-lb. minimum.

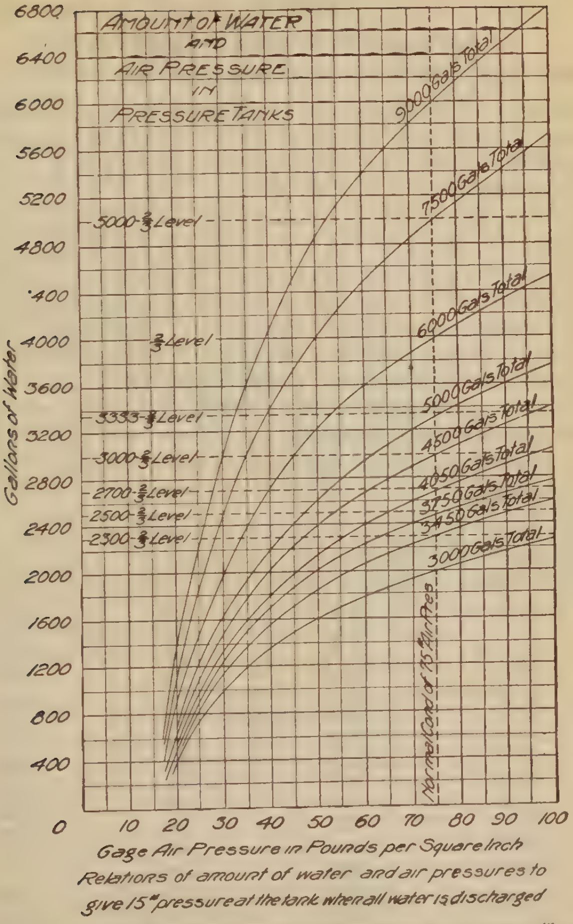


FIG. 170. AMOUNT OF WATER AND AIR PRESSURE IN PRESSURE TANKS

Note: This diagram can be used as follows: A 6,000-gal. tank when containing 4,000 gals. of water requires a 75-lb. initial pressure. If portion of water has been discharged, say 1,000 gals., the remaining 3,000 gals. (see intersection of 6,000 gal. tank curve and 3,000 gal. horizontal line), will be under 45-lb. pressure. See also Table 24 and 26.

TABLE 29

RATINGS FOR DUPLEX STEAM PUMPS

Note—Figures given are for actual displacement, less 10 per cent. for slip.

Pumps with 10-inch stroke are figured at 75 revolutions per minute. Pumps with 12-inch stroke are figured at 70 revolutions per minute. Pumps with 16-inch stroke are figured at 60 revolutions per minute.

For fire or heavy pressure service the ratio of steam to water cylinders should not be less than 3 to 1. If less than this, steam pumps cannot, generally speaking, be relied upon for such service, and any rating given such pumps would be misleading. With pumps of the same size, the "Underwriter" pattern can generally be relied upon for one-fourth to one-third greater discharge than the ordinary trade pattern. Owing to the effect which various sized piston rods would have in the displacements, the figures given below are not absolutely correct, but they will be found near enough for practical purposes. They are given to the nearest ten gallons.

Diameter of Water Cylinder.	10-inch Stroke.	12-inch Stroke.	16-inch Stroke.
5	210	240	280
6	310	350	410
7	430	490	560
7¼	470	530	610
7½	500	560	650
8	570	640	720
8½	650	730	830
9	730	820	940
9¼	770	860	990
9½	780	900	1,040
10	880	990	1,150
10¼	920	1,040	1,210
10½	970	1,100	1,260
11	1,070	1,210	1,380
11½	1,170	1,320	1,520
12	1,280	1,450	1,650

TABLE 30

HEIGHTS IN FEET TO WHICH PUMPS WILL ELEVATE WATER

Steam pressure, 50 pounds per square inch at the pump.
No allowance made for friction in pipes, etc.

Diameter of Steam Cylinders	Diameter of Water Cylinders.																
	2 Inch	2½ Inch	3 Inch	3½ Inch	4 Inch	5 Inch	6 Inch	7 Inch	8 Inch	9 Inch	10 Inch	10½ Inch	12 Inch	14 Inch	16 Inch	18 Inch	20 Inch
3½	230	147	102	75	58	37											
4	300	192	134	134	75	48	34										
5	469	300	209	153	117	75	52	38									
6	675	432	300	221	169	108	75	55	42	33							
7	920	588	408	300	230	147	102	75	57	45	37						
8	...	768	533	344	300	192	141	98	75	59	48	44					
9	...	972	675	496	380	243	169	124	95	75	61	55	42				
10	...	...	833	612	469	300	208	153	117	94	75	68	50	38			
12	...	...	...	881	675	432	300	220	169	133	108	97	75	55	42		
14	...	...	...	...	920	588	408	300	228	182	147	133	102	75	57	45	
16	...	...	...	...	...	768	564	392	300	236	192	174	141	98	75	59	48
18	...	...	...	...	...	972	650	490	379	300	243	220	162	122	95	75	61
20	...	...	...	...	...	...	833	600	469	370	300	272	208	150	117	92	75
22	...	...	...	...	...	...	1008	741	567	448	364	329	252	185	142	112	91
24	...	...	...	...	...	...	...	882	675	533	432	392	300	220	169	133	108
26	...	...	...	...	...	...	...	1034	788	626	508	460	356	258	197	156	127
28	...	...	...	...	...	...	...	...	919	726	588	533	407	300	230	181	147
30	...	...	...	...	...	...	...	...	1054	834	676	612	468	345	263	208	169
32	...	...	...	...	...	...	...	...	...	948	798	697	533	391	300	237	192
34	...	...	...	...	...	...	...	...	...	1070	868	786	603	442	339	268	217
36	...	...	...	...	...	...	...	...	...	...	972	881	675	495	380	300	243

The maximum limit of piston speed depends upon the head pumped against.

TABLE 31

THEORETICAL HORSE-POWER REQUIRED TO RAISE WATER TO DIFFERENT HEIGHTS

Feet	10	20	30	40	50	100	200	300	400	Feet
Gals. per Min.										Gals. per Min.
10	.025	.050	.075	.10	.12	.25	.50	.75	1.00	10
20	.050	.100	.150	.20	.25	.50	1.00	1.50	2.00	20
30	.075	.150	.225	.30	.37	.75	1.50	2.25	3.00	30
40	.100	.200	.300	.40	.50	1.00	2.00	3.00	4.00	40
50	.125	.250	.375	.50	.62	1.25	2.50	3.75	5.00	50
100	.250	.500	.750	1.00	1.25	2.50	5.00	7.50	10.00	100
150	.375	.750	1.125	1.50	1.87	3.75	7.50	11.25	15.00	150
200	.500	1.000	1.500	2.00	2.50	5.00	10.00	15.00	20.00	200
250	.625	1.250	1.875	2.50	3.12	6.25	12.50	18.75	25.00	250
300	.750	1.500	2.250	3.00	3.75	7.50	15.00	22.50	30.00	300
350	.875	1.750	2.625	3.50	4.37	8.75	17.50	26.25	35.00	350
400	1.000	2.000	3.000	4.00	5.00	10.00	20.00	30.00	40.00	400
500	1.250	2.500	3.750	5.00	6.25	12.50	25.00	37.50	50.00	500

TABLE 32

GALLONS OF WATER DISCHARGED PER REVOLUTION BY SINGLE CYLINDER PUMPS

Stroke in Inches.	Diameter of Cylinder in Inches.														
	5.	6.	7.	7½.	8.	8½.	9.	9¼.	9½.	10.	10¼.	10½.	11.	11½.	12.
8	1.36	1.96	2.67	3.06	3.48	3.93	4.41	4.66	4.92	5.44	5.72	6.00	6.58	7.19	7.83
8¼	1.40	2.02	2.75	3.15	3.59	4.05	4.55	4.80	5.07	5.61	5.90	6.19	6.79	7.41	8.07
8½	1.44	2.08	2.84	3.25	3.70	4.17	4.68	4.95	5.23	5.78	6.08	6.37	6.99	7.64	8.32
8¾	1.48	2.14	2.92	3.35	3.81	4.30	4.82	5.09	5.38	5.95	6.25	6.56	7.20	7.86	8.56
9	1.53	2.21	3.00	3.44	3.92	4.42	4.96	5.24	5.53	6.12	6.43	6.75	7.40	8.09	8.81
9¼	1.57	2.27	3.08	3.54	4.03	4.54	5.10	5.38	5.69	6.29	6.61	6.94	7.61	8.31	9.05
9½	1.61	2.33	3.17	3.64	4.14	4.66	5.23	5.53	5.84	6.46	6.79	7.12	7.81	8.54	9.30
9¾	1.65	2.39	3.25	3.73	4.25	4.79	5.37	5.67	5.99	6.63	6.97	7.31	8.02	8.76	9.54
10	1.69	2.45	3.33	3.83	4.36	4.91	5.51	5.82	6.15	6.80	7.14	7.50	8.22	8.99	9.79
10¼	1.74	2.51	3.41	3.93	4.47	5.03	5.65	5.96	6.30	6.97	7.32	7.69	8.43	9.21	10.0
10½	1.78	2.57	3.50	4.02	4.58	5.16	5.78	6.11	6.45	7.14	7.50	7.87	8.63	9.44	10.3
10¾	1.82	2.63	3.58	4.12	4.69	5.28	5.92	6.25	6.61	7.31	7.68	8.06	8.84	9.66	10.5
11	1.87	2.70	3.66	4.22	4.80	5.40	6.06	6.40	6.76	7.48	7.86	8.25	9.04	9.89	10.8
11¼	1.91	2.76	3.75	4.31	4.91	5.53	6.20	6.54	6.91	7.65	8.03	8.44	9.25	10.1	11.0
11½	1.95	2.82	3.83	4.41	5.02	5.65	6.33	6.69	7.07	7.82	8.21	8.62	9.45	10.3	11.3
11¾	1.99	2.88	3.92	4.51	5.13	5.77	6.47	6.83	7.22	7.99	8.39	8.81	9.66	10.6	11.5
12	2.04	2.94	4.00	4.60	5.23	5.89	6.61	6.98	7.37	8.16	8.57	9.00	9.87	10.8	11.8
13	2.20	3.19	4.33	4.98	5.66	6.38	7.16	7.56	7.97	8.83	9.29	9.75	10.7	11.7	12.7
14	2.38	3.44	4.66	5.36	6.10	6.87	7.71	8.14	8.57	9.50	10.0	10.5	11.5	12.6	13.7
15	2.55	3.68	5.00	5.74	6.53	7.36	8.26	8.72	9.17	10.1	10.7	11.2	12.3	13.5	14.7
16	2.72	3.93	5.33	6.12	6.98	7.85	8.81	9.30	9.77	10.8	11.5	12.0	13.1	14.4	15.6
17	2.89	4.17	5.67	6.50	7.41	8.34	9.36	9.88	10.4	11.5	12.2	12.7	13.9	15.3	16.6
18	3.06	4.42	6.00	6.88	7.84	8.83	9.92	10.5	11.0	12.2	12.9	13.5	14.8	16.2	17.6
24	4.07	5.88	8.00	9.16	10.5	11.8	13.2	14.0	14.6	16.2	17.2	18.0	19.7	21.6	23.4

TABLE 32—(Continued)

Note—The figures in table give the theoretical number of gallons of water which would be discharged in one revolution of the piston of a single cylinder pump, i. e., a forward and return stroke. No allowance has been made for slip or for the reduction in water discharged due to the space occupied by the piston rod, which will reduce the volume of discharge on the return stroke by an amount depending on the diameter of the piston rod and the length of stroke.

The following table must, therefore, be used in connection with the above and the figure which corresponds to the diameter of piston and stroke must be deducted from the table:

GALLONS DEDUCTED PER REVOLUTION FOR PISTON RODS

Diameter of Piston.	Stroke.		
	10 inch.	12-inch.	16-inch.
1½-inch	.08	.09	.12
2-inch	.13	.16	.22
2½-inch	.21	.26	.34
3-inch	.31	.36	.50

For other diameters and strokes approximations may be made.

For duplex pumps, in order to obtain the theoretical discharge, the figures obtained by the above tables must be multiplied by two.

TABLE 33

GENERAL HYDRAULIC DATA

A gallon of water (United States standard) weights 8 1/3 pounds and contains 231 cubic inches, or .134 cubic feet.

1,000 gallons of water weighs 4 1/6 tons approx.

240 gallons of water weighs approx. 1 ton of 2,000 pounds.

A cubic foot of water weighs 62½ pounds and contains 7.48 gallons.

To find pressure in pounds per square inch due to head, multiply height in feet by .434 or divide by 2.31.

To find height in feet, multiply pressure in pounds per square inch by 2.31 or divide by .434. (Continued on next page.)

To obtain capacity in gallons of a circular tank or cistern, multiply the square of the diameter in inches by the depth in inches and this product by .0034.

To find area of a circle multiply the square of the diameter by .7854 or the square of the radius by 3.1416.

A miner's inch of water is approximately equal to a supply of 11.22 gallons per minute.

TABLE 34

CAPACITY OF WROUGHT PIPE

Nominal Internal Diameter in Inches.	Actual Internal Diameter in Inches.	Capacity of One-Foot Length of Pipe in Gallons.
¾	.824	.0277
1	1.048	.0448
1¼	1.38	.0777
1½	1.611	.106
2	2.067	.174
2½	2.468	.248
3	3.067	.384
3½	3.648	.514
4	4.026	.661
5	5.045	1.04
6	6.065	1.50

Note: The outside diameters of pipes are fixed in order that they may fit the dies. The weight of pipe for a unit of length determines the inside diameter. The above figures are approximately correct for all such pipe of ordinary thickness.

The sprinkler rules state that the range in gallons of pipe capacity per sprinkler will be from .741 to 1.714 with the following averages; not including long runs from dry valve to system:

Centre feed........................	1.1	gals. per head
Side and end centre feed............	1.25	gals. per head
Panel construction....................	1.6	gals. per head

See also Table 35.

TABLE 35

AMOUNT OF WATER IN SPRINKLER PIPING

EXAMPLES OF CAPACITIES OF SYSTEM

Method of Piping.	Width of Bay in Feet.	Floor Dimensions in Feet.	No. of Sprinklers, One Floor.	Capacity Floor of Sprinkler Piping, Including Riser.	Gallons per Sprinkler.
Center Central Feed . .	12	120 x 200	204	240 gallons	1.17
Center Central Feed . .	10	96 x 200	160	183 gallons	1.14
Side Central Feed	10	72 x 300	285	290 gallons	1.02
Side Central Feed	10	60 x 120	60	75 gallons	1.25

Note—Height of floors, 12 feet. Pipe sizes as per 1-2-4 standard.

Center Central Feed (2 Risers).	12	120 x 216	270	334 gallons	1.24
Center Central Feed . .	10	80 x 160	128	135 gallons	1.05
Side Central Feed	10	60 x 200	120	188 gallons	1.56
Side Central Feed	10	50 x 100	50	58 gallons	1.16

Note—Pipe sizes as per 1-2-3 standard.

General Note: The above are specific examples of sprinkler piping capacity for 1–2–4 and 1–2–3 systems. For usual present conditions, see table 34 and its note.

TABLE 36

STATIC PRESSURE OF WATER

Head in Feet.	Pressure Lbs. per Sq. In.	Head in Feet.	Pressure Lbs. per Sq. In.	Head in Feet.	Pressure Lbs. per Sq. In.
1	0.43	55	23.87	150	65.10
2	0.87	60	26.04	175	75.95
3	1.30	65	28.21	200	86.80
4	1.74	70	30.38	250	108.50
5	2.17	75	32.55	300	130.20
10	4.34	80	34.72	350	151.90
15	6.51	85	36.89	400	173.60
20	8.68	90	39.06	450	195.30
25	10.85	95	41.23	500	217.00
30	13.02	100	43.40	600	260.40
35	15.19	110	47.74	700	303.80
40	17.36	120	52.08	800	347.20
45	19.53	130	56.42	900	390.60
50	21.70	140	60.76	1,000	434.00

TABLE 37

METRIC CONVERSION TABLE

Prefixes

The following prefixes are used in the Metric System for subdivisions and multiples: Milli = 1/1000; centi = 1/100; deci = 1/10; deca = 10; hecta = 100; kilo = 1000; myria = 10,000.

Measures of Length

1 meter = 39.37 inches, or 3.28083 feet, or 1.09361 yards.
.3048 meter = 1 foot.
1 centimeter = .3937 inch.
2.54 centimeters = 1 inch.
1 millimeter = .03937 inch, or 1/25 inch nearly.
25.4 millimeters = 1 inch.
1 kilometer = 1093.61 yards, or 0.62137 mile.

Measures of Area

1 Centare (1 sq. meter) = 1550 sq. inches.
1 Are (100 sq. meters) = 119.6 sq. yards.
1 Hectare (10,000 sq. meters) = 2.471 acres.

Measures of Capacity

1 cubic centimeter = 0.061 cubic inch.
1 cubic inch = 16.383 cubic centimeters.
1 cubic decimeter (1 liter) = 61.022 cubic inches, or 33.84 fluid ounces, or 1.0567 quarts, or 0.264 gallon.
1 fluid ounce = .2955 liter.
1 quart = .9463 liter.
1 gallon = 3.7878 liters.
1 cubic meter = 35.315 cubic feet, or 264.2 gallons.
1 cubic foot = .028316 cubic meter.

Measures of Weight

1 gram = 15.432 grains, or .0388 fluid ounce, or .03527 ounce avoirdupois.
1 grain = .0648 gram.
1 fluid ounce = 25.7732 grams.
1 ounce avoirdupois = 28.3527 grams.
1 kilogram (weight of 1 liter of water) = 2.2046 pounds.
1 pound = 0.4536 kilograms.

Measures of Heat

1 calorie = .2524 B.T.U.
1 B.T.U. = 3.968 calories.

Measures of Temperature

1° Centigrade = 1.8° Fahrenheit.
0° Centigrade = 32° Fahrenheit.
(Degrees C. × 9/5) + 32 = Degrees F.
(Degrees F. — 32) × 5/9 = Degrees C.

TABLE 38

MELTING POINTS OF VARIOUS SUBSTANCES

(Many of these soften at much lower temperatures than those given below)

Name of Substance	Degrees F.	Degrees C	Authority
Aluminum	1,120 ± 2	658 ± 1	Smithsonian Physical Tables
"	1,202 to 1,499	650 to 815	Wagner
"	1,157	625	Roberts-Austen
Antimony	1,166 ± 2	630 ± 1	S—P—T
"	810	432	Haswell
"	810 to 1,150	432 to 621	Kent
Bismuth	518	270	S—P—T
"	504 to 507	262 to 264	Kent
Brass	1,616	880	Schwartz
Bronze	1,692	922	Haswell and Kent
Beeswax	142 to 154	61 to 68	Kent
Cadmium	610	321	S—P—T
"	442	228	Kent
Copper	1,981 ± 5	1,083 ± 3	S—P—T
"	1,996	1,091	Haswell and Kent
Glass	2,377	1,303	Haswell
Gold	1,945 ± 5	1,063 ± 3	S—P—T
"	1,913	1,045	Roberts-Austen
"	2,156	1,069	Haswell
Iron	2,786	1,530	S—P—T
"	2,012 to 2,786	1,100 to 1,530	Kent
" (Cast)	2,000	1,093	Haswell
" (Cast, Gray)	2,210	1,210	Pouillet
" (Cast, White)	1,922	1,050	Kent
" " "	2,075	1,135	Roberts-Austen
" (Cast, Second Melting)	2,450	1,343	Haswell
" " " "	3,700	2,038	Rankine
" (Wrought)	2,732 to 2,912	1,500 to 1,600	Kent
" "	3,500	1,931	Rankine
Lead	622	327	S—P—T
"	608	320	Haswell and Kent
Nickel	2,646	1,452	S—P—T
"	2,732	1,500	Schwartz
Platinum	3,191 ± 36	1,755 ± 20	S—P—T
"	3,200	1,760	Haswell
Silver	1,762 ± 1	961 ± 1	S—P—T
"	1,733	945	Roberts-Austen
"	1,873	1,023	Kent
Steel	2,500	1,371	Haswell
"	2,372 to 2,532	1,300 to 1,389	Kent
" (Mild)	2,687	1,475	Roberts-Austen
" (Hard)	2,570	1,410	" "
Tallow	92	33	Haswell and Kent
Tin	450	232	S—P—T
"	442 to 446	228 to 230	Kent
"	446	230	Haswell
Wax (White)	142	61	"
Zinc	786	419	S—P—T
"	779	415	Roberts-Austen
"	782	416	Bell

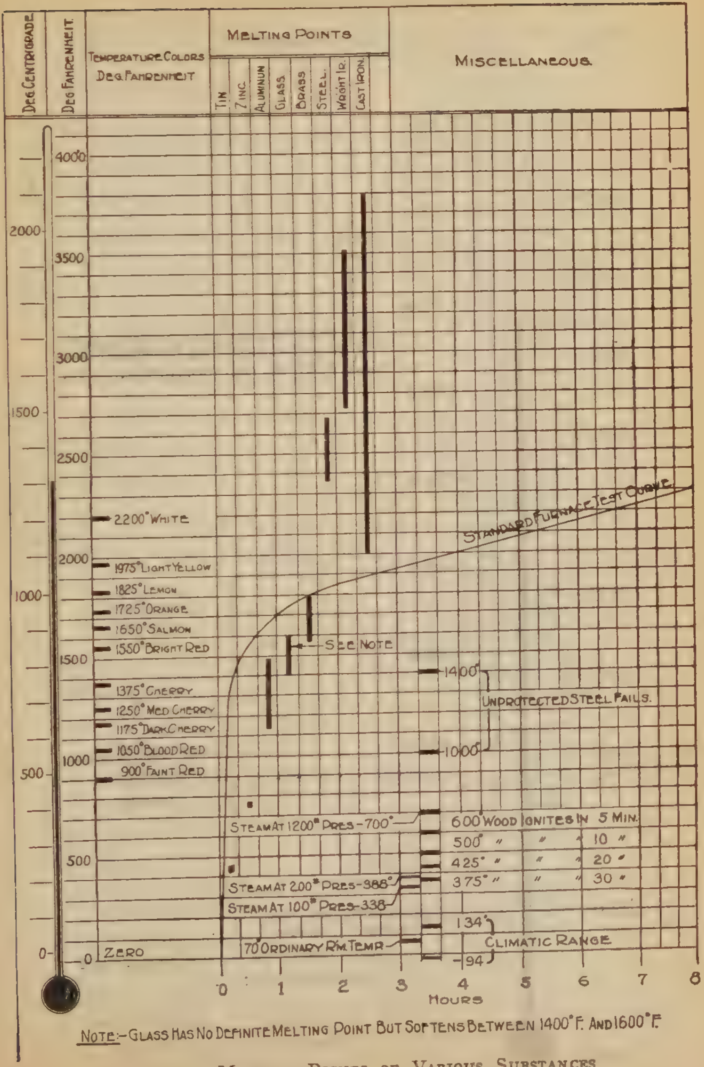


FIG 171. MELTING POINTS OF VARIOUS SUBSTANCES
(Courtesy of H. P. Weaver)

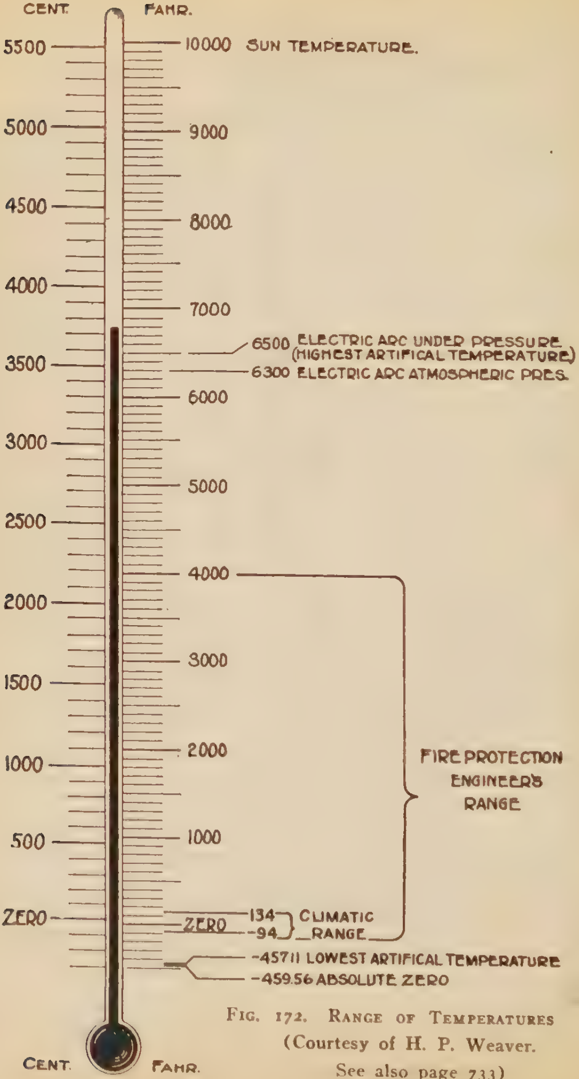


Fig. 172. Range of Temperatures
(Courtesy of H. P. Weaver.
See also page 733)

TABLE 39

WEIGHTS OF GASES AND VAPORS COMPARED TO AIR

(1) Lighter than Air (Roof Ventilation)

0.069	Hydrogen (g)
0.400–0.600	Coal gas (g)
0.553	Pit gas (Firedamp) (g)
0.588	Ammonia (g)
0.622	Water vapor (v)
0.700	Wood gas (g)
0.898	Acetylene (g)
0.945	Hydrocyanic acid (g)
0.967	Ethylene (g)
0.967	Carbon monoxide (g)

Water gas, generator gas, Dowson gas, power gas, and similar gases differ considerably in density according to their composition, but are all lighter than air.

0.987–1.015	Mond gas (according to the coal used)
0.510	Water gas
0.830–1.000	Generator gas

(2) Heavier than Air (Floor Ventilation)

1.036	Ethane (g)
1.039	Nitric oxide (g)
1.105	Oxygen (g)
1.120	Methyl alcohol (v)
1.185	Phosphuretted hydrogen (g)
1.192	Sulphuretted hydrogen (g)
	Air gas (carburetted air) (v):
1.260	With 10% of hydririne
1.275	With 11½% of hydririne
1.317	With 14% of hydririne
1.382	Allylene (g)
1.451	Propylene (g)
1.520	Propane (g)
1.527	Nitrous oxide (g)
1.530	Ethyl aldehyde (v)
1.590	Hyponitrous acid (g)
1.613	Alcohol (v)
1.617	Methyl ether (g)
1.738	Methyl chloride (g)
1.800	Cyanogen (g)
1.935	Butylene (g)
2.004	Butane (g)
2.104	Carbon oxysulphide (g)
2.200	Sulphur (v)
2.448	Chlorine (g)
2.565	Ether (v)
2.645	Carbon disulphide (v)
2.697	Arseniuretted hydrogen (v)
2.770	Benzol (v)
2.784	Seleniuretted hydrogen (g)
3.147	Amyl alcohol (v)
4.215	Chloroform (v)
4.355	Phosphorus (v)
4.498	Telluretted hydrogen (g)
5.700	Selenium (v)
6.650	Sulphur vapor
8.896	Tellurium (v)

Note—(g) indicates gas; (v), vapor.
From Von Schwartz, Fire and Explosion Risks.

TABLE 40. Explosion Temperature of Gases

	Degrees C.		Degrees C.
Acetylene	509–515	Hydrogen	555
Carbon disulphide vapor	100–170	Methane	656–678
Carbon monoxide	636–814	Oxyhydrogen gas	620–700
Coal gas	647–649	Under Pressure	518–606
Ethane	605–622	Propane	545–548
Ethylene	577–599	Propylene	497–511

Note: Pure gases will explode at these temperatures without air. Mixed with air, the explosion temperature is generally much lower.

From Von Schwartz, Fire and Explosion Risks

TABLE 41. Explosion Range of Gases

Name	Flame Ignition ° C.		Electric Ignition ° C.	
	Per Cent Gas to Air	Range of Explosibility	Per Cent Gas to Air	Range of Explosibility
Acetylene	3–82	79	3.2–52.2	49.0
Alcohol Vapor			4.0–13.6	9.6
Benzine Vapor	2.6–4.8	2.2	2.5–4.8	2.3
Benzol Vapor	3–6	3	2.7–6.3	3.6
Carbon Disulphide	6 downwards	Approx.		
Carbon Monoxide	13–75	62	16.6–74.8	58.2
Carburetted Air (Air Gas)	9–26	17		
Coal Gas	8–23	15	8.0–19.0	11.0
Ether Vapor	6 downwards	Approx.	2.9–7.5	4.6
Ethylene	4–22	18	4.2–14.5	10.3
Hydrogen	7–75	68	9.5–66.5	57.0
Methane	5–13	8	6.2–12.7	6.5
Pentane			2.5–4.8	2.3
Toluol	2.5–5	2.5		
Water Gas	9–55	46	12.5–66.6	54.1

From Von Schwartz, Fire and Explosion Risks.

TABLE 42

COMPARATIVE TABLE OF THERMOMETERS

1 Fahrenheit degree = 5/9 deg. Cent. = 4/9 deg. Reaumur
1 Centigrade degree = 9/5 deg. Fahr. = 4/5 deg. Reaumur
1 Reaumur degree = 9/4 deg. Fahr. = 5/4 deg. Cent.
Temp. Fahrenheit = 9/5 × temp. C. + 32 deg. = 9/4 R. + 32 deg.
Temp. Centigrade = 5/9 (temp. F. — 32 deg.) = 5/4 R.
Temp. Reaumur = 4/5 temp. C. = 4/9 (F. — 32 deg.)
Freezing point: Reaumur = 0 deg.; Cent. = 0 deg.; Fahr. = 32 deg.
Boiling point: Reaumur = 80 deg.; Cent. = 100 deg.; Fahr. = 212 deg.

Continued on page 737

TABLE 42—(Continued)

Cent.	Fahr.	Reau.	Cent.	Fahr.	Reau.	Cent.	Fahr.	Reau.
−18	0	−14	107	225	86	234	455	187
−15	5	−12	110	230	88	237	460	190
−12	10	−10	113	235	90	240	466	192
− 9	16	− 7	116	241	93	242	469	194
− 7	19	− 6	118	244	94	245	475	196
− 4	25	− 3	121	250	97	248	480	198
− 1	30	− 1	124	255	99	251	486	201
2	36	2	127	261	102	253	489	202
5	41	4	129	264	103	256	495	205
7	45	6	132	270	106	259	500	207
10	50	8	134	275	107	262	505	210
13	55	10	137	280	110	265	511	212
16	61	13	140	284	112	267	514	214
18	64	14	142	289	114	270	520	216
21	70	17	145	295	116	273	525	218
24	75	19	148	300	118	276	531	221
27	81	22	151	306	121	278	534	222
29	84	23	153	309	122	281	540	225
32	90	26	156	315	125	284	545	227
35	95	28	159	320	127	287	550	230
38	100	30	162	325	130	290	556	232
41	106	33	165	331	132	292	559	234
43	109	34	167	334	134	295	565	236
46	115	37	170	340	136	298	570	238
49	120	39	173	345	138	301	576	241
52	126	42	176	351	141	303	579	242
54	129	43	178	354	142	306	585	245
57	135	46	181	360	145	309	590	247
60	140	48	184	365	147	312	595	250
63	145	50	187	370	150	315	601	252
66	151	53	190	376	152	317	604	254
68	154	54	192	379	154	320	610	256
71	160	57	195	385	156	323	614	258
74	165	59	198	390	158	326	620	261
77	171	62	201	396	161	329	625	263
79	174	63	203	399	162	332	630	266
82	180	66	206	405	165	335	636	268
85	185	68	209	410	167	337	639	270
88	190	70	212	415	170	340	645	272
91	196	73	215	421	172	343	650	274
93	199	75	217	424	174	346	656	277
96	205	77	220	430	176	348	659	278
99	210	79	223	435	178	351	665	281
102	216	82	226	441	181	354	670	283
104	219	83	228	444	182	357	675	286
			231	450	185	360	681	288

TABLE 43

FLUIDS USED IN THE ARTS

Data secured principally from Underwriters' Laboratories

	Name.	Formula.	Specific Gravity at 15.5° C.	Flash Point Closed Cup.	
				Deg. C.	Deg. F.
1	Acetate—amyl	$CH_5CO_2C_5H_{11}$	.857	32	90
2	ethyl	$CH_3CO_2C_2H_5$	.924		
3	methyl	$CH_3CO_2CH_3$	.957 at 0° C.		
4	Acetone	CH_3COCH_3	.792	− 20	− 4
5	Alcohol—amyl (fusel oil)	$C_5H_{11}OH$	.825 at 0° C.	42	107
6	ethyl (grain)	CH_5OH	.7939	12	53
7	methyl (wood)	CH_3OH	.7959	12	53
8	Aniline Oil	$C_6H_5NH_2$	1.022 at 20° C.	76	169
9	Benzol	C_6H_6	.879 at 20° C.	− 27	− 17
10	Carbon Disulphide	CS_2	1.292	− 30	− 22
11	Chloroform	$CHCl_3$	1.526		
12	Ether—ethyl	$(C_2H_5)_2O$	.719	− 45	− 49
13	petroleum	C_5H_{12}; C_6H_{14}	.650; .700		
14	Gasolene	C_6H_{14}; C_8H_{14}	.700; .750	− 18	0
15	Glycerin	$C_3H_5(OH)_3$	1.260 at	176	351
16	Kerosene	$C_{10}H_{22}$; $C_{16}H_{34}$	.750; .775	37	98
17	Naphthalene	$C_{10}H_8$	1.145 at 4° C.	85	185
18	Nitro Benzol	$C_6H_5NO_2$	1.20 at 3° C.	90	194
19	Pyridene	C_5H_5N	.989	20	68
20	Toluol	$C_6H_5CH_3$	.882 at 0° C.	8	47
21	Xylol	$C_6H_4(CH_3)_2$	.862	80	176

TABLE 43—Continued

Boiling Point.		Apparent Ignition Temp.		Explosive Range.	Freezing Point.		Vapor Density Air = 1.	Air Vol. to Burn 1 Vol. Vapor.	% Vapor in Air for Combustion.	
Deg. C.	Deg. F.	Deg. C.	Deg. F.		Deg. C.	Deg. F.				
1.5	34				−134	−209	4.49			1
77.1	171				−83.8	−118	3.04	19.0	5.0	2
57.5	136				− 82	−115	2.56			3
56.1	133			2.0–9.0	− 95	−139	2.01	19.0	5.0	4
138	281						3.04			5
78.4	173	435	887	4.0–13.0	−117	−178	1.59			6
64.7	148				− 97	−142	1.10	7.15	12.25	7
184	365				− 6	21	3.22	9.56	9.5	8
80.2	176	500	932	2.7–6.3	5.5	42	2.7	35.7	2.72	9
46.2	115	100	212		−116	−176	2.6	14.3	6.53	10
61.2	142						4.13			11
34.6	94	180	356	3.0–7.5	−117	−178	2.6	28.6	3.38	12
60 to 90	140 to 194						2.5–3.0			13
90 to 150	194 to 304	280	536	1.4–6.0			3.0–3.5			14
290	556				17	63	3.18	57.1	1.72	15
150 to 300	304 to 574	250	482				4.0–8.0			16
218.2	426				79	174	4.42			17
211	413						4.25	36.9	2 64	18
115.5	240				− 42	− 43	2.73	23.8	4.03	19
111	232				− 92	−133	3.14	42.9	2.28	20
139	283						3.66			21

TABLE 44

VEGETABLE OILS

Name.	Specific Gravity.	Flash Point, Closed Cup.	
		Deg. C.	Deg. F.
Castor Oil	.964	281	540
Corn Oil	.922	248	480
Cottonseed Oil	.925	210	412
Linseed Oil—Boiled		192	378
Linseed Oil—Raw	.930	242	469
Olive Oil	.918	246	477
Palm Oil	.920	216	422
Peanut Oil	.917	292	560
Rape Oil	.913	265	510
Rosin Oil	.984	130	266
Turpentine	.860	43	110

TABLE 45

ANIMAL AND FISH OILS

Name.	Specific Gravity.	Flash Point, Closed Cup.	
		Deg. C.	Deg. F.
Bone Oil		253	490
Cod Liver Oil			
Lard Oil (Pure)	.9175	255	494
Menhaden Oil		173	345
Neats Foot Oil	.9142	253	490
Oleo Oil		313	598
Red Oil	.904	188	372
Seal Oil	.920	251	486
Sperm Oil	.8815	235	455
Tallow Oil	.943	253	490
Whale Oil	.927	245	475

Note: Some of the oils listed in Tables 44 and 45 have been credited with a very wide range in flash points by different authorities. The figures used represent averages in such cases.

TABLE 46

RELATIVE TENDENCY TO SPONTANEOUS IGNITION OF FATS

Vegetable Fats.	Iodine Value.	Animal Fats.	Iodine. Value.
Linseed Oil (Raw)	170	Codliver Oil	140
Hemp Oil	150	Seal Oil	127
Nut Oil	146	Japan Liver Oil	120
Poppy Oil	138	Goose Fat	71
Olein	138	Bone Fat	68
Cotton Seed Oil	108	Hog Fat, American	62
Sesame Oil	106	Hog Fat, German	58
Rape Oil	101	Tallow	42
Ground-nut Oil	96	Mutton Tallow	42
Castor Oil	84	Wool Fat	36
Olive Oil	82	Butter Fat	30
Palm Oil	52		
Cocoa Butter	36		
Palm Kernel Oil	14		
Cocoanut Oil	9		

Note: The best basis for establishing the relative spontaneous heating tendency of fats is claimed by Von Schwartz to be the relative ability per 100 grams of fats to absorb iodine.

Boiled linseed oil is more hazardous than raw.

Rancid animal fats and oils are more dangerous than pure vegetable oils.

From Von Schwartz, Fire and Explosion Risks

TABLE 47

EXPLOSION TEMPERATURES OF BLASTING MATERIALS

Name	Degrees C.
Blasting Gelatine	203–209
Blasting Gelatine with Camphor	174–182
Celluloid	195
Cellulose Dynamite	169–230
Collodion Wool, Air-dry	186–199
Dynamite	197–200
Gun Cotton, Air-dry	137–139
Gun Cotton, Compressed	186–201
Kieselguhr with 50 per cent. Nitroglycerin	180–230
Mercury Fulminate	175–187
Nitroglycerin	257
Picric Acid	300

From Von Schwartz, Fire and Explosion Risks

TABLE 48

SUMMARY OF FREEZING TEMPERATURE RECORDS

Ten Stations in Southern States, Covering a Period of Ten Years, 1891-1900, Inclusive, Taken From Records of the United States Weather Bureau, Washington, D. C.

(Tabulated by Capt. W. H. Stratton, ex-Manager of the Factory Insurance Association)

Figures Cover a Period of Ten Years, 1891 to 1900, Inclusive.							Total 6 Months.			Total 5 Months. Nov. to Mar. Inclusive.			Total 3 Months. Dec. to Feb. Inclusive.		
Station.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Total.	Whole Number of Days.	Per cent. of Freezing Weather.	Total.	Whole Number of Days.	Per cent. of Freezing Weather.	Total.	Whole Number of Days.	Per cent. of Freezing Weather.
Lynchburg, Va.	11	75	173	192	163	92	706	1,639	43%	695	1,360	51%	528	811	65%
Charlotte, N. C.	3	44	124	144	106	47	468	1,731	27 "	465	1,421	31 "	374	842	44 "
Wilmington, N. C.	0	21	64	68	59	15	227	1,550	14 "	227	1,271	17 "	191	753	25 "
Raleigh, N. C.	5	46	119	140	121	61	492	1,640	30 "	487	1,361	35 "	380	812	46 "
Charleston, S. C.	0	5	24	42	36	5	112	1,732	7 "	112	1,422	8 "	102	843	11 "
Augusta, Ga.	1	27	88	97	79	23	315	1,670	19 "	314	1,360	25 "	264	811	32 "
Montgomery, Ala.	0	20	62	92	57	23	254	1,640	15 "	254	1,361	18 "	211	812	26 "
Mobile, Ala.	0	8	40	56	36	6	146	1,640	9 "	146	1,361	10 "	132	812	16 "
Meridian, Miss.	5	37	65	94	69	39	309	1,184	26 "	304	998	30 "	228	601	37 "
Vicksburg, Miss.	0	21	41	72	49	13	196	1,546	12 "	196	1,267	15 "	162	750	21 "
Total	25	304	800	997	775	324	3,225			3,200			2,572		
Whole Number of Days	2,790	2,669	2,756	2,666	2,425	2,666		15,972			13,182			7,847	
Per cent. of Freezing Weather	$\frac{8}{10}$ of 1%	11%	29%	37%	31%	12%			20%			24%			32%

TABLE 49

SPRINKLER FIRE TABLES

The following tables are from the 1923 report of the National Fire Protection Association:

SECTION I

Summary of Unsatisfactory Sprinkler Fires

	1922–1923		1897–1923, incl.	
	No. of Fires	Per Cent	No. of Fires	Per Cent
Water shut off sprinklers	28	33.8	360	29.3
Generally defective equipment	6	7.2	249	20.0
Unsprinklered portions	4	4.8		
Defective water supply or supplies	5	6.0	111	9.3
Sprinkler system crippled due to freezing	2	2.4	41	3.3
Slow operation of dry system or defective valve	7	8.5	33	2.7
Slow or defective operation of high test heads	3	3.6	22	1.8
Faulty building construction, concealed spaces, vertical openings, etc.	6	7.2	62	5.1
Obstruction to distribution	7	8.5	70	5.7
Hazard of occupancy too severe for average sprinkler equipment	8	9.6	70	5.7
Explosion crippled sprinkler system			55	4.5
Exposure or conflagration			71	5.8
Plugged heads (included with Miscellaneous prior to 1921)	3	3.6	6	.5
Miscellaneous	4	4.8	77	6.3
Total	83		1227	

Special Classification of Fires in Which Failure Was Due to Water Being Shut Off Sprinklers

	1922–1923 No. of Fires	1897–1923 No. of Fires
Water shut off for unknown reason, neglect, carelessness	7	134
Water shut off before fire was out or fire rekindled	6	54
Water shut off due to accidents or repairs	3	60
Water shut off to prevent freezing	7	73
Water shut off, probably incendiary		6
Water shut off, leaky dry system		11
Water shut off, miscellaneous	3	15
Water shut off, defective gate valve	2	7
Total	28	360

SECTION II

Annual Revision of Sprinkler Fire Tables

In the following eleven tables is given a summary of fires occurring in properties equipped with automatic sprinklers. The total number of such fires reported during the past year is 2,550, which includes 624 fires where no sprinklers were opened. Several reports were also received in which the data was incomplete, and these were not used in the summary. It may be noted that the total number of fires does not agree throughout all the tables. This is because some of the reports of fires prior to 1909 were not considered sufficiently complete to include in all the tables, and hence appear in some tables, but not in others.

Table No. 1—Time of Day

	1922–1923		1897–1923	
	No. of Fires	Per Cent	No. of Fires	Per Cent
6 a. m. to 6 p. m.	959	50.1	15008	56.6
6 p. m. to 6 a. m.	954	49.9	11535	43.4
Total with data given	1913		26543	
No data	13		463	
Total	1926		27006	

Table No. 2—How Discovered

	1922–1923		1897–1923	
	No. of Fires	Per Cent	No. of Fires	Per Cent
Employee	846	44.0	15075	57.1
Watchman	246	12.8	3901	14.8
Sprinkler Alarm	565	29.4	4654	17.6
Outsider	141	7.3	1436	5.4
Thermostats	30	1.6	779	2.9
Supervisory System	95	4.9	589	2.2
Total with data given	1923		26434	
No data	3		572	
Total	1926		27006	

Table No. 3—Efficiency of Alarm Service, 1922–1923

Note: This table does not include fires where alarm service does or does not operate promptly if fire is at once discovered by employees, the alarm service having no bearing on such fires one way or the other.

	Satisfactory.		Failure.		Total.
	No. of Fires.	Per Cent.	No. of Fires.	Per Cent.	
Watchman alone	119	95.2	6	4.8	125
Sprinkler Alarm alone	375	98.7	5	1.3	380
Thermostats alone	4	100.0	..	..	4
Supervisory System alone	1	100.0	..	..	1

	Watchman.		Sprinkler Alarm.		Thermostat.		Supervisory.		Total.
	Satisfactory.	Failure.	Satisfactory.	Failure.	Satisfactory.	Failure.	Satisfactory.	Failure.	
Watchman and Sprinkler Alarm	127	98	213	12	..	..	..	..	225
Sprinkler Alarm and Thermostats	..	..	20	2	20	2	..	..	22
Watchman, Sprinkler Alarm and Thermostats	3	3	6	..	4	2	..	..	6
Sprinkler Alarm and Supervisory	..	..	130	2	..	..	132	..	132
Watchman, Sprinkler Alarm and Supervisory	6	40	46	..	..	..	46	..	46
Sprinkler Alarm, Thermostats and Supervisory	..	..	9	..	7	2	9	..	9

Efficiency of Alarm Service, 1897–1923, Inclusive

	Satisfactory.		Failure.		Total.
	No. of Fires.	Per Cent.	No. of Fires.	Per Cent.	
Watchman alone	2207	90.9	220	9.1	2427
Sprinkler Alarm alone	2823	95.3	139	4.7	2962
Thermostats alone	221	81.5	50	18.5	271
Supervisory alone	60	98.5	1	1.5	61

Efficiency of Alarm Service, 1897–1923—Continued

	Watchman.		Sprinkler Alarm.		Thermostat.		Supervisory.		Total.
	Satisfactory.	Failure.	Satisfactory.	Failure.	Satisfactory.	Failure.	Satisfactory.	Failure.	
Watchman and Sprinkler Alarm	1639	1108*	2448	299	..	..	..	..	2747
Watchman and Thermostats	20	10*	..	..	28	2	..	..	30
Sprinkler Alarm and Thermostats	..	..	579	45	490	134	..	..	624
Watchman, Sprinkler Alarm and Thermostats	49	84*	124	9	99	34	..	..	133
Sprinkler Alarm and Supervisory	..	..	761	15	..	..	768	8	776
Watchman and Supervisory	12	9*	..	..	..	..	21	..	21
Watchman, Sprinkler Alarm and Supervisory	106	280*	375	11	..	..	374	12	386
Sprinkler Alarm, Thermostats and Supervisory	..	..	86	3	74	15	88	1	89
Watchman, Sprinkler Alarm, Supervisory and Thermostats	1	1	2	..	2	..	2	..	2

* These include fires where sprinkler alarm or thermostat notified the watchman.

TABLE NO. 4

NUMBER OF SPRINKLERS OPERATING

No. of Sprinklers Operating.	No. of Fires, 1922–1923.							No. of Fires, 1897–1923, incl.						
	Wet.	%	Dry.	%	No Data.	Total.	%	Wet.	%	Dry.	%	No Data.	Total.	%
1	638	40.9	51	15.9	4	693	36.6	8346	35.7	922	19.4	13	9281	32.9
2	290	18.5	54	10.9	2	346	18.2	4121	17.7	659	13.8	4	4784	17.0
3	158	10.1	26	8.1	2	186	9.8	2360	10.1	400	8.4	2	2762	9.8
4	111	7.1	22	6.9		133	7.0	1679	7.2	350	7.3	3	2032	7.2
5	72	4.6	12	3.7		84	4.4	1063	4.6	220	4.6	2	1285	4.6
6	45	2.9	16	5.0	1	62	3.3	854	3.6	211	4.4	3	1068	3.8
7	37	2.4	14	4.4		51	2.7	582	2.5	150	3.1	1	733	2.6
8	33	2.1	7	2.2		40	2.1	551	2.4	140	2.9		691	2.5
9	19	1.2	6	1.9		25	1.3	352	1.5	103	2.2		455	1.6
10	16	1.0	7	2.2		23	1.2	326	1.4	95	2.0	1	422	1.5
11	13	.9	11	3.4		24	1.3	244	1.0	89	1.9		333	1.2
12	10	.6	5	1.6	1	16	.9	285	1.2	100	2.1	1	386	1.4
13	10	.6	6	1.9		16	.9	154	.7	77	1.6		231	.8
14	8	.5	4	1.3		12	.6	180	.8	73	1.5	1	254	.9
15	12	.8	8	2.5		20	1.1	148	.6	74	1.5	1	223	.8
16 to 20	24	1.5	15	4.7		39	2.0	510	2.2	219	4.6	2	731	2.6
21 to 25	5	.3	16	5.0		21	1.1	301	1.3	162	3.4		463	1.6
26 to 30	13	.9	9	2.8		22	1.2	227	1.0	102	2.2		329	1.2
31 to 35	7	.4	5	1.6		12	.6	146	.6	66	1.4	1	213	.8
36 to 40	10	.6	7	2.2		17	.9	125	.5	63	1.3		188	.7
41 to 50	7	.4	2	.6	1	10	.5	154	.7	93	1.9	1	248	.9
51 to 75	8	.5	5	1.6	1	14	.7	207	.9	121	2.5	1	329	1.2
76 to 100	6	.4	1	.3		7	.4	87	.4	58	1.2	1	146	.5
Over 100	12	.8	11	3.4		23	1.2	318	1.4	229	4.8		547	1.9
No Data	13		9		8	30		24		20		382	426	
Total	1577		329		20	1926		23344		4796		420	28560	
Water shut off sprinklers													270	
Total													28830	

TABLE NO. 5

NUMBER OF SPRINKLERS OPERATING

No. of Sprinklers Operating.	No. of Fires 1897–1923, incl.						
	Wet.	%	Dry	%	No Data	Total.	%
1	8346	35.8	922	19.3	13	9281	33.0
2 or less	12467	53.5	1581	31.2	17	14065	50.0
3 or less	14827	63.6	1981	41.5	19	16827	60.0
4 or less	16506	70.8	2331	48.8	22	18859	67.1
5 or less	17569	75.3	2551	53.5	24	20144	71.6
6 or less	18423	79.0	2762	57.9	27	21212	75.5
7 or less	19005	81.6	2912	60.9	28	21945	78.0
8 or less	19556	83.6	3052	64.0	28	22636	80.6
9 or less	19908	85.4	3155	66.1	28	23091	82.4
10 or less	20234	86.8	3250	68.1	29	23513	83.6
11 or less	20478	87.8	3339	69.8	29	23846	84.9
12 or less	20763	88.9	3439	72.0	30	24232	86.3
13 or less	20917	89.6	3516	73.5	30	24463	87.0
14 or less	21097	90.5	3589	75.1	31	24717	87.8
15 or less	21245	91.2	3663	76.7	32	24940	88.7
20 or less	21755	93.1	3882	81.3	34	25671	91.4
25 or less	22056	94.6	4044	84.5	34	26134	92.7
30 or less	22283	95.6	4146	86.6	34	26463	94.2
35 or less	22429	96.4	4212	88.3	35	26676	94.9
40 or less	22554	96.6	4275	89.5	35	26864	95.6
50 or less	22708	97.4	4368	91.3	36	27112	96.5
75 or less	22915	98.2	4489	94.0	37	27441	97.7
100 or less	23002	98.7	4547	95.2	38	27587	98.0
Over 100	318	1.3	229	4.8		547	2.0
No Data	24		20		382	426	
	23344		4796		420	28560	
Water shut off sprinklers						270	
Total						28830	

TABLE NO. 6

EFFECT OF SPRINKLERS, WET AND DRY SYSTEMS

	1922–1923.							1897–1923, incl.						
	No. of Fires.		No. of Fires.			No. of Fires.		No. of Fires.		No. of Fires.			No. of Fires.	
	Wet.	%	Dry.	%	No Data.	Total.	%	Wet.	%	Dry.	%	No Data.	Total.	%
Practically or entirely extinguished	1143	72.6	202	61.5	6	1351	70.2	15861	66.5	3127	63.6	19	19007	66.0
Held fire in check	390	24.7	99	30.0	3	492	25.5	7111	29.8	1461	29.8	11	8583	29.7
Total Satisfactory	1533	97.3	301	91.5	9	1843	95.7	22972	96.3	4588	93.4	30	27590	95.7
Unsatisfactory	44	2.7	28	8.5	11	83	4.3	879	3.7	325	6.6	20	1224	4.3
Total	1577		329		20	1926		23851		4913		50	28814	

TABLE NO. 7

PRIMARY WATER SUPPLIES TO SPRINKLERS OPENED

	1922–1923.		1897–1923, incl.	
	No. of Fires.	Per Cent.	No. of Fires.	Per Cent.
Waterworks	955	50.3	13758	52.5
Gravity Tank	332	17.5	6400	24.4
Pressure Tank	515	27.1	4626	17.6
Pumps	96	5.1	1409	5.4
Steamer Connection	..	..	3	1
Total with data given	1898		26196	
No Data	28	..	540	..
Water shut off system	..		270	
Total	1926		27006	

TABLE NO. 8

SHOWING EFFECT OF SPRINKLERS BY CLASS OF OCCUPANCY

	Extinguished Fire.		Held Fire in Check.		Total Satisfactory.		Unsatisfactory.		Total No. of Fires.
	No.	%	No.	%	No	%	No.	%	
Agricultural Implements	52	57.7	34	37.8	86	95.5	4	4.5	90
Alcohol (Wood) Plant	..	....	1	100.0	1	100.0	..	..	1
Apartments	15	93.8	1	6.2	16	100.0	..	..	16
Artificial Leather	10	50.0	8	40.0	18	90.0	2	10.0	20
Automobile and Bicycle Factories	114	57.5	75	37.9	189	95.4	9	4.6	198
Awning Factories	5	71.5	2	28.5	7	100.0	..	..	7
Bag Factories	13	56.5	10	43.5	23	100.0	..	..	23
Bakeries	69	72.6	23	24.2	92	96.8	3	3.2	95
Basket Factories	7	87.5	1	12.5	8	100.0	..	..	8
Bolt, Nut and Screw Works	17	65.5	9	34.5	26	100.0	..	..	26
Boot and Shoe Shops	562	73.7	173	22.8	735	96.5	27	3.5	762
Bottling Works	4	80.0	..	....	4	80.0	1	20.0	5
Braiding Mills	16	84.2	3	15.8	19	100.0	...	..	19
Breweries	5	83.4	1	16.6	6	100.0	..	..	6
Broom Factories	10	58.7	5	29.4	15	88.1	2	11.9	17
Brush Factories	17	77.3	5	22.7	22	100.0	..	..	22
Button Factories	42	82.4	7	13.7	49	96.1	2	3.9	51
Candle Factories	5	50.0	5	50.0	10	100.0	..	..	10
Candy Factories	111	71.6	39	25.2	150	96.8	5	3.2	155
Canning Factories	10	58.8	4	23.5	14	82.3	3	17.7	17
Car Houses	28	46.7	25	41.7	53	88.4	7	11.6	60
Car Works	70	60.9	41	35.6	111	96.5	4	3.5	115
Carpet Mills	159	61.9	89	34.6	248	96.5	9	3.5	257
Carriage and Automobile Body Factories	101	60.8	51	30.8	152	91.6	14	8.4	166
Celluloid (Pyroxylin Plastic)	135	66.7	43	21.3	178	88.0	24	12.0	202
Cement and Plaster Works	4	66.6	1	16.7	5	83.3	1	16.7	6
Cereal Mills	32	65.3	12	24.5	44	89.8	5	10.2	49
Chemical and White Lead	91	58.0	52	33.1	143	91.1	14	8.9	157
Clothing Factories	942	83.2	183	16.1	1125	99.3	8	.7	1133
Clubs	7	77.8	2	22.2	9	100.0	..	..	9
Coffee and Spice Mills	47	66.4	21	29.6	68	96.0	3	4.0	71
Coffin Factories	50	76.9	13	20.0	63	96.9	2	3.1	65
Cold Storage Plants	5	55.6	4	44.4	9	100.0	..	..	9
Cooperage Plants	47	56.0	27	32.1	74	88.1	10	11.9	84
Cordage Works	208	65.3	100	31.2	308	96.5	11	3.5	319
Cork Factories	14	48.2	12	41.4	26	89.6	3	10.4	29
Corset Factories	8	66.7	3	25.0	11	91.7	1	8.3	12
Cotton Ginnery	10	62.5	6	37.5	16	100.0	..	..	16
Cotton Mills	3924	62.0	2342	37.0	6266	99.0	72	1.0	6338
Cotton Warehouses	145	46.2	142	45.5	287	91.7	26	8.3	313
Cotton Seed Oil Mills	39	48.8	28	35.0	67	83.8	13	16.2	80
Cutlery and Tools	23	63.9	11	30.6	34	94.5	2	5.5	36
Department Stores	390	78.3	95	19.1	485	97.4	13	2.6	498
Distilleries	7	63.7	3	27.2	10	90.9	1	9.1	11
Dolls	19	51.4	18	48.6	37	100.0	..	..	37
Drug Houses	169	80.5	37	17.6	206	98.1	4	1.9	210
Dry Cleaning Establishments	6	66.7	3	33.3	9	100.0	..	..	9
Dyeing, Bleaching and Finishing	146	53.7	113	41.5	259	95.2	13	4.8	272

TABLE NO. 8—Continued

	Extinguished Fire.		Held Fire in Check.		Total Satisfactory.		Unsatisfactory.		Total No. of Fires.
	No.	%	No.	%	No.	%	No.	%	
Electrical Appliances	153	71.5	55	25.7	208	97.2	6	2.8	214
Electric Light and Power Plants	4	33.3	6	50.0	10	83.3	2	16.7	12
Elevators, Grain	26	37.7	26	37.7	52	75.4	17	24.6	69
Excelsior Factories	24	77.4	5	16.1	29	93.5	2	6.5	31
Fertilizer Plants	23	62.2	11	29.7	34	91.9	3	8.1	37
Flax and Linen Mills	26	47.2	29	52.8	55	100.0	..	..	55
Flour and Grist Mills	55	55.0	34	34.0	89	89.0	11	11.0	100
Forge and Smithy	16	69.6	6	26.1	22	95.7	1	4.3	23
Foundries	150	58.4	96	37.4	246	95.8	11	4.2	257
Fur Works	27	90.0	3	10.0	30	100.0	..	..	30
Furniture Factories	503	65.1	213	27.5	716	92.6	59	7.4	775
Garages	139	66.8	64	30.8	203	97.6	5	2.4	208
Garbage Reduction Plants	3	60.0	1	20.0	4	80.0	1	20.0	5
Gas Plants	2	66.7	1	33.3	3	100.0	..	..	3
Glass Works	50	52.6	35	36.8	85	89.4	10	10.6	95
Glove Factories	9	69.2	3	23.1	12	92.3	1	7.7	13
Glue Factories	6	50.0	4	33.3	10	83.3	2	16.7	12
Groceries	69	80.2	12	13.8	81	94.0	5	6.0	86
Harness and Fancy Leather	93	82.4	20	17.6	113	100.0	..	..	113
Hat Factories	149	74.1	45	22.4	194	96.5	7	3.5	201
Hatters' Fur Works	12	52.2	8	34.8	20	87.0	3	13.0	23
Hotels	25	73.5	8	23.5	33	97.0	1	3.0	34
Ice Plants	2	100.0	..	....	2	100.0	..	..	2
Incandescent Lamp Factories	13	54.2	11	45.8	24	100.0	..	..	24
Institutions	8	66.7	3	25.0	11	91.7	1	8.3	12
Insulated Wire Factories	31	66.0	16	34.0	47	100.0	..	..	47
Jewelry Factories	126	87.5	12	8 3	138	95.8	6	4.2	144
Junk Shops	17	73.9	5	21.7	22	95.6	1	4.4	23
Knitting Mills, Cop Yarn	40	61.6	19	29.2	59	90.8	6	9.2	65
Knitting Mills, Full Process	477	64.3	240	32.3	717	96.6	25	3.4	742
Laundries	52	73.2	16	22.5	68	95.7	3	4.3	71
Lead Pencil Factories	16	66.7	7	29.2	23	95.9	1	4.1	24
Linseed Oil Works	17	56.7	11	36.7	28	93.4	2	6.6	30
Machine Works	350	68.1	141	27.4	491	95.5	23	4.5	514
Match Factories	51	73.9	14	20.3	65	94.2	4	5.8	69
Mattress Factories	339	71.0	131	27.5	470	98.5	7	1.5	477
Mercantile	866	81.1	181	16.0	1047	98.0	22	2.0	1069
Metal Reduction Works	8	66.7	4	33.3	12	100.0	..	..	12
Metal Workers	800	64.8	385	31.2	1185	96.0	50	4.0	1235
Miscellaneous	443	70.6	153	24.4	596	95.0	31	5.0	627
Morocco Leather Shops	32	52.5	21	34.4	53	86.9	8	13.1	61
Motion Pictures	51	78.4	13	20.0	64	98.4	1	1.6	65
Munition Factories	20	39.2	22	43.2	42	82.4	9	17.6	51
Musical Instrument Factories	114	66.6	51	29.8	165	96.4	6	3.6	171
Office Buildings	21	80.6	5	19.4	26	100.0	..	..	26
Oil Clothing Factories	11	68.8	5	31.2	16	100.0	..	..	16
Oilcloth and Linoleum Works	32	29.9	56	52.3	88	82.2	19	17.8	107
Oil Refineries									
Animal	2	40.0	3	60.0	5	100.0	..	..	5
Mineral	5	83.4	1	16.6	6	100.0	..	..	6
Vegetable	1	14.3	5	71.4	6	85.7	1	14.3	7

TABLE NO. 8—Continued

	Extinguished Fire.		Held Fire in Check.		Total Satisfactory.		Unsatisfactory.		Total No. of Fires.
	No.	%	No.	%	No.	%	No.	%	
Packing House and Slaughter	129	69.4	50	26.9	179	96.3	7	3.7	186
Paint and Color Works	156	69.6	60	26.8	216	96.4	8	3.6	224
Paper Box and Papeterie	156	75.0	48	23.1	204	98.1	4	1.9	208
Paper Mills	365	50.1	305	41.9	670	92.0	59	8.0	729
Patent Leather Works	7	33.3	10	47.6	17	80.9	4	19.1	21
Phonograph Works	18	75.0	5	20.8	23	95.8	1	4.2	24
Photographic Works	22	75.8	6	20.7	28	96.5	1	3.5	29
Picture Frame Factories	39	64.0	16	26.2	55	90.2	6	9.8	61
Plumbers' Supplies	20	80.0	5	20.0	25	100.0	..	..	25
Potteries	44	63.7	21	30.4	65	94.1	4	5.9	69
Printing and Lithographing	579	80.5	122	17.0	701	97.5	17	2.5	718
Pulp Mills	30	35.3	39	45.9	69	81.2	16	18.8	85
Restaurants	42	82.4	8	15.7	50	98.1	1	1.9	51
Rice Mills	1	50.0	1	50.0	2	100.0	..	..	2
Rolling, Wire and Tube Works	26	57.8	17	37.8	43	95.6	2	4.4	45
Roofing Works	23	36.5	34	53.9	57	90.4	6	9.6	63
Rubber Cloth Factories	26	60.5	17	39.5	43	100.0	..	..	43
Rubber Reclaiming Works	6	35.3	9	52.9	15	88.2	2	11.8	17
Rubber Works	130	49.6	115	43.9	245	93.5	17	6.5	262
Saw and Planing Mills	81	43.8	61	32.9	142	76.7	43	23.3	185
Schools	7	70.0	3	30.0	10	100.0	..	..	10
Shirt Factories	45	86.5	7	13.5	52	100.0	..	..	52
Shoddy Mills	192	65.7	80	27.4	272	93.1	20	6.9	292
Silk Mills	75	74.3	22	21.8	97	96.1	4	3.9	101
Skin Mills	2	66.7	1	33.3	3	100.0	..	..	3
Soap Manufacturing	34	79.0	8	18.6	42	97.6	1	2.4	43
Stamping and Sheet Metal Works	58	61.8	29	30.9	87	92.7	7	7.3	94
Starch and Glucose Works	12	52.3	4	17.4	16	69.7	7	30.3	23
Sticky Fly Paper Factories	3	75.0	1	25.0	4	100.0	..	..	4
Sugar Refineries	20	64.5	10	32.3	30	96.8	1	3.2	31
Tanneries	43	52.5	32	39.0	75	91.5	7	8.5	82
Tenant Manufacturing	635	73.8	180	20.9	815	94.7	46	5.3	861
Theatres	45	72.6	14	22.6	59	95.2	3	4.8	62
Tobacco Factories	51	69.9	19	26.1	70	96.0	3	4.0	73
Trunk Factories	15	68.2	5	22.7	20	90.9	2	9.1	22
Varnish Works	18	58.0	11	35.5	29	93.5	2	6.5	31
Wall Paper Factories	13	68.5	3	15.8	16	84.3	3	15.7	19
Warehouses	329	70.6	114	24.4	443	95.0	23	5.0	466
Waste and Batting Mills	245	61.3	140	35.0	385	96.3	15	3.7	400
Waste Paper and Rag Shops	68	62.5	38	34.8	106	97.3	3	2.7	109
Weaving Mills	115	65.6	56	32.0	171	97.6	4	2.4	175
Whip Factories	4	66.7	2	33.3	6	100.0	..	..	6
Window Shade Factories	10	83.4	..	....	10	83.4	2	16.6	12
Woodworkers, Class A*	139	53.9	83	32.2	222	86.1	36	13.9	258
Woodworkers, Class B*	144	52.2	104	37.7	248	89.9	28	10.1	276
Woodworkers, Class C*	125	60.6	71	34.5	196	95.1	10	4.9	206
Woodworkers, Class D*	87	58.0	44	29.3	131	87.3	19	12.7	150
Woodworkers, Class E*	143	63.8	70	31.3	213	95.1	11	4.9	224
Woodworkers, Class F*	34	60.8	18	32.1	52	92.9	4	7.1	56
Woolen Mills	896	70.4	315	24.8	1211	95.2	61	4.8	1272
Wool Storehouses	27	71.1	9	23.6	36	94.7	2	5.3	38
Worsted Mills	55	51.4	38	35.5	93	86.9	14	13.1	107
Total Sprinkler Fires	19,008		8,579		27,587		1,227		28,814

TABLE NO. 8—Concluded

* The Woodworkers are classed as follows:

Class A. Interior Woodwork, builders' supplies (including veneer works).

Class B. Box Factories (including cigar boxes).

Class C. Miscellaneous Woodworkers. Steam power tenant Woodworkers (also Woodworkers where there is a lack of detailed information as to class).

Class D. Sash, Door, and Blind Factories.

Class E. Hard Wood Turning (wheels, pipes, novelties, bobbins, spools, etc., last and wood-heel factories).

Class F. Pails and Woodenware. (Plates, wooden bowls, tubs, etc.)

52| 73.4
16| 66.7|

TABLE NO. 9

CLASSIFICATION OF UNSATISFACTORY SPRINKLER FIRES BY OCCUPANCY

	Water shut off sprinklers.	Generally defective equipment and unsprinklered portions.	Defective water supply or supplies.	Sprinkler system crippled due to freezing.	Slow operation of dry system or defective dry valve.	Slow or defective operation of high test heads.	Faulty building construction, concealed spaces, vertical openings.	Obstruction to distribution.	Hazard of occupancy too severe for average sprinkler equipment.	Sprinkler system crippled by explosion.	Exposure or conflagration.	Plugged Heads.	Miscellaneous.	Total.
Agricultural Implements	3	..	..	..	..	..	..	..	1	..	..	..	..	4
Artificial Leather	..	..	..	..	..	..	1	..	..	1	..	..	..	2
Automobile and Bicycle	4	1	1	..	..	..	..	2	..	..	1	..	..	9
Bakeries	1	1	..	..	..	..	..	..	..	..	..	..	1	3
Boot and Shoe Shops	10	5	2	..	..	1	..	1	..	2	5	..	1	27
Bottling Works	..	1	..	..	..	..	..	..	..	..	..	..	..	1
Broom Factories	2	..	..	..	..	..	..	..	..	..	..	..	..	2
Button Factories	..	..	..	2	..	..	..	..	..	..	..	..	..	2
Candy Factories	2	..	..	..	1	..	2	..	..	..	..	..	..	5
Canning Works	1	..	..	..	1	..	..	..	..	..	1	..	..	3
Car Houses	2	2	1	..	1	..	..	1	..	..	..	..	..	7
Car Works	1	1	..	..	..	..	1	1	..	..	..	..	..	4
Carpet Mills	4	1	3	..	..	..	..	1	..	..	..	..	..	9
Carriage Factories	2	4	3	..	1	..	..	1	1	..	2	..	..	14
Celluloid (Pyroxylin)	1	..	3	1	1	..	2	2	7	5	2	..	..	24
Cement and Plaster Works	..	..	..	..	1	..	..	..	..	..	..	..	..	1
Cereal Mills	..	2	1	..	..	..	..	..	..	2	..	..	..	5
Chemical and White Lead	2	4	..	..	..	..	..	..	4	4	..	..	..	14
Clothing Factories	3	..	1	1	..	..	2	1	..	..	..	..	..	8
Coffee and Spice Mills	2	..	..	..	..	..	..	..	..	1	..	..	..	3
Coffin Factories	1	..	..	1	..	..	..	..	..	..	..	..	..	2
Cooperage Plants	1	3	..	..	..	1	..	4	..	..	1	..	..	10

TABLE NO. 9—Continued

	Water shut off sprinklers.	Generally defective equipment and unsprinklered portions.	Defective water supply or supplies.	Sprinkler system crippled due to freezing.	Slow operation of dry system or defective dry valve.	Slow or defective operation of high test heads.	Faulty building construction, concealed spaces, vertical openings.	Obstruction to distribution.	Hazard of occupancy too severe for average sprinkler equipment.	Sprinkler system crippled by explosion.	Exposure or conflagration.	Plugged Heads.	Miscellaneous.	Total.
Cordage Works	2	4	1	1	..	..	..	2	..	..	..	..	1	11
Cork Factories	1	..	1	..	..	..	..	..	..	1	..	..	..	3
Corset Factories	..	..	..	..	..	..	..	..	..	..	1	..	..	1
Cotton Mills	25	18	6	2	..	1	5	1	3	..	..	2	9	72
Cotton Warehouses	14	1	2	..	..	..	1	4	2	..	..	..	2	26
Cotton Seed Oil Mills	3	4	2	..	..	..	..	..	1	..	..	..	3	13
Cutlery and Hardware	1	1	..	..	..	..	..	..	..	..	..	..	..	2
Department Stores	4	3	..	..	1	..	1	1	..	..	2	..	1	13
Distilleries	..	..	..	..	..	..	..	..	..	..	1	..	..	1
Drug Houses	..	..	..	..	..	..	..	..	..	..	3	..	1	4
Dyeing, Bleaching and Finishing	4	3	1	..	1	1	..	1	..	..	1	..	1	13
Electrical Appliances	2	..	2	..	..	..	1	..	..	..	..	..	1	6
Electric Light and Power Plants	..	1	..	..	..	..	..	1	..	..	..	..	..	2
Elevators, Grain	..	3	5	..	1	..	2	1	1	1	2	..	1	17
Excelsior Factories	..	..	1	..	..	..	..	..	1	..	..	..	..	2
Fertilizer Plants	2	..	..	..	1	..	..	..	..	..	..	..	..	3
Flour and Grist Mills	1	2	1	..	1	..	1	..	..	3	2	..	..	11
Forge and Smithy	..	..	..	..	..	..	..	1	..	..	..	..	..	1
Foundries	8	1	1	..	..	..	..	..	..	1	..	..	..	11
Furniture Factories	19	13	2	3	..	..	2	9	7	..	4	..	..	59
Garages	3	..	..	..	..	..	..	2	..	..	..	..	..	5
Garbage Reduction Plants	1	..	..	..	..	..	..	..	..	..	..	..	..	1
Glass Works	1	1	2	1	..	..	1	1	..	..	..	..	3	10
Glove Factories	1	..	..	..	..	..	..	..	..	..	..	..	..	1

TABLE NO. 9—Continued

	Water shut off sprinklers.	Generally defective equipment and unsprinklered portions.	Defective water supply or supplies.	Sprinkler system crippled due to freezing.	Slow operation of dry system or defective dry valve.	Slow or defective operation of high test heads.	Faulty building construction, concealed spaces, vertical openings.	Obstruction to distribution.	Hazard of occupancy too severe for average sprinkler equipment.	Sprinkler system crippled by explosion.	Exposure or conflagration.	Plugged Heads.	Miscellaneous.	Total.
Glue Factories	1	..	..	..	..	..	..	..	1	..	..	..	..	2
Groceries	3	..	1	..	1	..	..	..	..	..	..	..	..	5
Hat Factory	2	3	1	..	1	..	..	..	..	..	..	..	..	7
Hatters' Fur Mfg.	2	..	..	..	..	..	1	..	..	..	..	..	..	3
Hotels	..	..	1	..	..	..	..	..	..	..	..	..	..	1
Institutions	..	..	..	..	1	..	..	..	..	..	..	..	..	1
Jewelry Shops	2	1	..	2	..	..	1	..	..	..	..	..	..	6
Junk Shops	1	..	..	..	..	..	..	..	..	..	..	..	..	1
Knitting, Cop Yarn	..	1	3	..	..	..	..	1	..	1	..	..	..	6
Knitting, Full Process	7	9	5	1	1	..	1	..	..	1	..	..	..	25
Laundries	2	..	..	..	..	..	..	1	..	..	..	..	..	3
Lead Pencil Works	..	..	..	..	..	..	..	..	..	1	..	..	..	1
Linseed Oil Works	..	..	..	..	..	..	..	..	..	2	..	..	..	2
Machine Shops	14	3	1	1	..	1	..	1	..	1	..	..	1	23
Match Factories	2	..	..	..	..	..	..	..	1	..	..	..	1	4
Mattress Factories	3	2	..	1	..	..	..	1	..	..	..	..	..	7
Mercantile	10	2	..	2	1	..	2	..	..	..	4	..	1	22
Metal Workers	16	13	2	..	..	1	3	3	4	2	2	1	3	50
Miscellaneous	7	5	3	1	1	2	2	1	4	2	2	..	1	31
Morocco Leather Shops	3	3	..	..	1	..	1	..	..	..	..	..	..	8
Motion Pictures	1	..	..	..	..	..	..	..	..	..	..	..	..	1
Munitions Factories	2	..	..	1	..	..	..	..	4	1	..	..	1	9
Musical Instrument Factories	1	3	..	..	..	..	1	..	..	..	1	..	..	6
Oilcloth and Linoleum Works	..	4	..	..	..	..	1	3	11	..	..	..	..	19

TABLE NO. 9—Continued

	Water shut off sprinklers.	Generally defective equipment and unsprinklered portions.	Defective water supply or supplies.	Sprinkler system crippled due to freezing.	Slow operation of dry system or defective dry valve.	Slow or defective operation of high test heads.	Faulty building construction, concealed spaces, vertical openings.	Obstruction to distribution.	Hazard of occupancy too severe for average sprinkler equipment.	Sprinkler system crippled by explosion.	Exposure or conflagration.	Plugged Heads.	Miscellaneous.	Total.
Oil Refinery	..	..	1	..	..	..	..	..	..	..	..	..	..	1
Packing House and Slaughter	1	2	1	..	2	..	..	..	..	..	..	..	1	7
Paint and Color Works	1	2	2	..	..	..	3	..	..	..	..	..	..	8
Paper Box and Papeterie	3	1	..	..	..	..	..	..	..	..	..	..	..	4
Paper Mills	11	19	6	3	..	2	2	..	3	1	2	1	9	59
Patent Leather Works	1	..	1	1	..	..	1	..	..	..	..	..	..	4
Phonograph Works	1	..	..	..	..	..	..	..	..	..	..	..	..	1
Photograph Works	1	..	..	..	..	..	..	..	..	..	..	..	..	1
Picture Frame Factories	1	2	1	1	..	..	..	1	..	..	..	..	..	6
Potteries	1	1	..	1	..	..	..	..	..	1	..	..	..	4
Printing and Lithographing	6	4	1	..	..	..	1	1	..	..	3	..	1	17
Pulp Mills	6	3	3	..	1	1	..	..	..	1	..	..	1	16
Restaurants	..	..	..	..	..	..	1	..	..	..	..	..	..	1
Rolling, Wire and Tube Works	..	..	..	..	..	..	1	..	..	..	..	..	1	2
Roofing Works	2	2	..	1	..	..	..	..	..	1	..	..	..	6
Rubber Reclaiming Works	1	..	..	..	..	..	1	..	..	..	..	..	..	2
Rubber Works	6	..	..	1	..	..	..	1	5	3	..	..	1	17
Saw and Planing Mills	11	7	1	..	4	1	6	2	3	..	5	1	2	43
Shoddy Mills	6	2	6	..	1	3	..	1	..	..	..	..	1	20
Silk Mills	2	1	..	..	..	..	..	..	..	1	..	..	..	4
Soap Manufacturing	..	1	..	..	..	..	..	..	..	..	..	..	..	1
Stamping and Sheet Metal Works	1	2	1	..	1	..	..	..	..	..	2	..	..	7
Starch and Glucose Mills	..	..	..	..	..	..	..	..	1	6	..	..	..	7
Sugar Refineries	..	..	..	..	..	..	..	..	..	1	..	..	..	1

TABLE NO. 9—Concluded

	Water shut off sprinklers.	Generally defective equipment and unsprinklered portions.	Defective water supply or supplies.	Sprinkler system crippled due to freezing.	Slow operation of dry system or defective dry valve.	Slow or defective operation of high test heads.	Faulty building construction, concealed spaces, vertical openings.	Obstruction to distribution.	Hazard of occupancy too severe for average sprinkler equipment.	Sprinkler system crippled by explosion.	Exposure or conflagration.	Plugged Heads.	Miscellaneous.	Total.
Tanneries	1	1	..	3	..	..	..	..	..	..	1	..	1	7
Tenant Manufacturing	22	7	2	2	1	..	2	1	1	..	6	..	2	46
Theatres	2	1	..	.	..	..	..	..	..	..	..	..	..	3
Tobacco Factories	1	1	..	..	..	..	..	..	..	..	1	..	..	3
Trunk Factories	1	1	..	..	..	..	..	..	..	..	..	..	..	2
Varnish Works	..	..	1	..	..	..	..	..	1	..	..	..	..	2
Wall Paper Factories	..	..	1	..	..	..	..	1	..	..	1	..	..	3
Warehouses	10	3	1	..	2	..	1	3	..	..	..	..	3	23
Waste and Batting Mills	3	4	3	1	..	1	..	1	1	..	..	..	1	15
Waste Paper and Rag Shops	2	1	..	..	..	..	..	..	..	..	..	..	..	3
Weaving Mills	1	1	1	1	..	..	..	..	..	..	..	..	..	4
Window Shade Factories	..	..	..	1	..	..	..	..	1	..	..	..	..	2
Woodworkers, Class A*	10	9	1	..	..	1	..	5	..	3	3	1	3	36
Woodworkers, Class B*	6	8	2	1	..	2	1	1	..	3	2	..	2	28
Woodworkers, Class C*	3	4	1	..	..	..	..	2	..	..	..	..	..	10
Woodworkers, Class D*	1	7	..	1	1	..	..	..	..	2	4	..	3	19
Woodworkers, Class E*	3	2	..	..	2	1	2	..	..	..	1	..	..	11
Woodworkers, Class F*	2	..	1	..	..	..	..	1	..	..	..	..	..	4
Woolen Mills	14	16	12	1	..	2	4	..	1	..	3	..	8	61
Wool Storehouses	..	2	..	..	..	..	..	..	..	..	..	..	..	2
Worsted Mills	3	3	2	1	..	..	1	..	..	..	..	..	4	14
Total Unsatisfactory Fires	360	240	111	14	33	22	62	70	70	55	71	6	77	1227

* See detailed classification of woodworkers on page 754.

TABLE NO. 10

SECONDARY WATER SUPPLIES TO SPRINKLER SYSTEM

Occupancy.		Secondary Supply.		Primary Supply.				Secondary Supply.					
	Total No. of Fires.	When a Factor.	% Total.	Waterworks.	Gravity Tanks.	Pressure Tank.	Misc. Pumps.†	Waterworks.	Gravity Tank.	Pressure Tank.	Steam Pump.	Misc. Pumps.†	Steamer Connection.
Agricultural Implements	90	3	3.3	3	..	..	..	..	..	..	2	1	..
Auto and Bicycle Fac.	198	6	3.0	2	1	1	2	2	3	..	..	1	..
Bag Factories	23	2	8.7	..	..	2	..	..	2	..	..	..	..
Bakeries	95	1	1.1	1	..	..	..	..	1	..	..	..	..
Bolt, Nut and Screw Works	26	2	7.7	1	..	..	1	1	..	..	1	..	..
Boot and Shoe Shops	762	14	1.8	9	3	2	..	2	6	1	3	2	..
Broom Factories	17	1	5.9	1	..	..	..	..	1	..	..	..	..
Button Factories	51	1	2.0	..	..	1	..	..	1	..	..	..	..
Candle Factories	10	1	1.0	..	..	1	..	..	1	..	..	..	..
Candy Factories	155	5	3.2	1	..	4	..	3	1	..	..	..	1
Car House	60	1	1.7	1	..	..	..	..	1	..	..	..	..
Car Works	115	3	2.6	2	1	..	..	..	..	..	3	..	..
Carpet Mills	257	5	1.9	3	2	..	..	1	..	..	3	1	..
Carriage Factories	166	16	9.6	10	1	5	..	2	8	..	3	2	1
Celluloid Works	202	15	7.4	13	1	1	..	..	5	..	8	1	1
Cement and Plaster	6	2	33.3	..	1	1	..	..	1	..	..	1	..
Cereal Mills	49	4	8.2	2	..	2	..	..	..	1	1	2	..
Chemical and White Lead	157	16	10.2	2	12	1	1	..	2	..	9	3	2
Clothing	1133	24	2.1	1	..	23	..	2	18	1	1	2	..
Coffin Factories	65	2	3.1	..	1	1	..	..	1	..	1	..	..
Cooperage Plants	84	6	7.1	1	..	5	..	3	3	..	..	..	..
Cordage Works	319	34	10.6	12	6	14	2	11	5	..	12	4	2
Cork Factories	29	1	3.5	..	1	..	..	..	..	..	1	..	..
Cotton Mills	6338	388	6.1	69	311	7	1	4	9	..	267	108	..
Cotton Warehouses	313	23	7.4	6	17	..	..	1	3	..	15	4	..
Cotton Seed Oil Mills	80	17	21.2	1	14	1	1	1	1	..	12	3	..
Department Stores	498	10	2.0	2	3	5	..	..	4	1	1	3	1
Distilleries	11	3	27.2	..	1	1	1	1	..	1	1	..	..
Drug Houses	210	10	4.8	5	..	5	..	..	7	..	1	..	2
Dyeing, Bleaching and Finishing	272	7	2.6	3	4	..	..	1	..	..	5	1	..
Electrical Appliances	214	4	1.9	3	..	1	..	..	..	..	3	1	..
Electric Light and Power	12	1	8.3	..	1	..	..	..	..	..	1	..	..
Elevators, Grain	69	17	24.6	2	5	8	2	2	1	..	8	6	..
Fertilizer Plants	37	7	18.9	1	2	3	1	1	2	..	3	1	..
Flour Mills	100	10	10.0	2	4	4	..	3	1	..	3	2	1
Foundries	257	5	1.9	3	2	..	..	1	1	..	3	..	..
Furniture Factories	775	51	6.6	23	9	18	1	11	16	..	16	5	3

TABLE NO. 10—Continued

Occupancy.		Secondary Supply.		Primary Supply.				Secondary Supply.					
	Total No. of Fires.	When a Factor.	% Total.	Waterworks.	Gravity Tanks.	Pressure Tank.	Misc. Pumps.†	Waterworks.	Gravity Tank.	Pressure Tank.	Steam Pump.	Misc. Pumps.†	Steamer Connection.
Garages	208	4	1.9	..	1	3	..	1	3	..	..	..	..
Glass Works	95	6	6.3	3	1	2	..	..	3	..	1	2	..
Glove Factories	13	1	7.7	1	..	..	..	1	..	..	..	..	..
Glue Factories	12	3	25.0	..	3	..	..	..	..	..	3	..	..
Harness and Fancy Leather	113	5	4.4	..	..	5	..	..	5	..	..	..	..
Hat Factories	201	9	4.5	2	3	4	..	1	3	1	3	..	1
Hatters' Fur Mfg.	23	1	4.4	1	..	..	..	..	1	..	..	..	..
Inc. Lamp Factories	24	1	4.2	..	1	..	..	1	..	..	..	..	..
Insulated Wire Factories	47	2	4.3	..	2	..	..	..	..	..	2	..	..
Junk Shops	23	2	8.7	1	..	1	..	..	2	..	..	..	..
Knitting Mills, Cop Yarn	65	2	3.1	..	2	..	..	..	..	..	1	1	..
Knitting Mills, F. P.	742	27	3.6	6	20	1	..	1	1	..	12	13	..
Linseed Oil Works	30	6	20.0	..	2	3	1	..	..	1	1	4	..
Machine Shops	514	11	2.1	1	3	7	..	2	2	..	6	1	..
Match Factories	69	4	5.8	..	1	1	2	3	..	..	..	1	..
Mattress Factories	477	19	4.0	2	9	8	..	4	4	..	9	..	2
Mercantile	1069	35	3.3	5	1	27	2	13	11	1	..	3	7
Metal Workers	1235	39	3.2	17	11	8	3	5	8	1	21	3	1
Miscellaneous	627	34	5.4	16	7	8	3	2	14	1	12	5	..
Morocco Leather	61	3	4.9	3	..	..	..	..	..	..	2	1	..
Motion Picture	65	3	4.6	1	1	1	..	..	1	1	1	..	..
Munition Factories	51	9	17.7	..	9	..	..	..	..	..	9	..	..
Musical Instrument Factories	171	8	4.7	2	2	4	..	..	6	..	1	1	..
Office Buildings	26	2	7.8	1	1	..	..	1	1	..	..	..	..
Oil Clothing Factories	16	1	6.3	..	..	1	..	1	..	..	..	..	..
Oil Cloth and Linoleum	107	38	35.6	9	26	..	3	4	4	..	23	7	..
Oil Refineries (Vegetable)	7	2	28.6	..	1	1	..	1	..	..	1	..	..
Packing House	186	11	5.9	6	3	2	..	2	1	..	3	4	1
Paint and Color Works	224	12	5.1	2	2	8	..	4	3	..	4	1	..
Paper Box	208	88	3.8	2	2	4	..	2	3	..	1	..	2
Paper Mills	729	65	8.9	22	37	1	5	3	2	..	45	15	..
Phonograph Works	24	1	4.2	..	..	1	..	..	1	..	..	..	..
Picture Frames	61	4	6.6	..	1	3	..	..	2	1	1	..	..
Plumber's Supplies	25	2	8.0	1	..	1	..	..	2	..	..	..	..
Potteries	69	3	4.3	..	1	..	2	..	2	..	1	..	..
Printing	718	9	1.2	2	3	4	..	2	5	..	1	..	1
Pulp Mills	85	12	14.1	7	3	1	1	1	..	..	10	1	..

TABLE NO. 10—Concluded

Occupancy.	Total No. of Fires.	Secondary Supply.		Primary Supply.				Secondary Supply.					
		When a Factor.	% Total.	Waterworks.	Gravity Tanks.	Pressure Tank.	Misc. Pumps.†	Waterworks.	Gravity Tank.	Pressure Tank.	Steam Pump.	Misc. Pumps.†	Steamer Connection.
Restaurants	51	1	2.0	..	..	1	..	..	1	..	..	..	..
Rolling, Wire and Tube Works	45	2	4.4	1	1	..	..	..	..	..	1	1	..
Roofing Works	63	9	14.2	4	5	..	..	..	3	..	5	..	1
Rubber Cloth Factories	43	2	4.6	1	1	..	..	..	..	..	1	1	..
Rubber Reclaiming Works	17	3	17.7	1	2	..	..	..	..	..	3	..	..
Rubber Works	262	11	4.2	3	7	1	..	1	..	..	4	5	1
Saw and Planing Mills	185	37	20.0	16	12	..	9	2	8		18	8	1
Schools	10	1	10.0	1	..	..	..	..	..	..	..	1	..
Shirt Factories	52	1	1.9	1	..	..	..	..	..	..	..	1	..
Shoddy Mills	292	15	5.1	10	3	1	1	..	3	..	9	3	..
Silk Mills	101	1	1.0	..	..	1	..	..	1	..	..	..	..
Skin Mills	3	1	33.3	1	..	..	..	..	..	..	..	1	..
Soap Manufacturing	43	2	4.6	1	1	..	..	1	..	1	..	..	..
Stamping and Sheet Metal Works	94	7	7.5	4	2	1	..	2	3	..	2	..	..
Tanneries	82	5	6.1	4	..	1	..	..	..	..	4	..	1
Tenant Manufacturing	861	14	1.6	1	2	9	2	1	8	2	3	.	..
Varnish Works	31	1	3.2	..	1	..	..	..	..	..	1	..	..
Wall Paper Factories	19	2	10.5	..	2	..	..	..	..	..	2	..	..
Warehouses	466	27	5.8	8	9	7	3	4	13	..	7	3	..
Waste and Batting Mills	400	15	3.7	7	3	5	..	3	3	.	3	3	3
Waste Paper and Rags	109	4	3.7	..	..	4	..	3	1	..	..	..	..
Weaving Mills	175	7	4.0	..	7	..	..	..	..	..	4	3	..
Woodworkers, Class A*	258	16	6.2	10	2	3	1	1	5	1	4	4	1
Woodworkers, Class B*	276	19	6.9	6	6	6	1	2	8	..	4	3	2
Woodworkers, Class C*	206	9	4.4	2	4	..	3	..	5	..	2	2	..
Woodworkers, Class D*	150	8	5.3	6	..	..	2	1	5	..	1	1	..
Woodworkers, Class E*	224	5	2.2	3	1	1	..	..	1	..	..	4	..
Woodworkers, Class F*	56	6	10.7	3	2	1	..	2	1	..	2	1	..
Woolen Mills	1272	74	5.8	25	40	3	6	2	10	..	30	32	..
Worsted Mills	107	2	1.9	1	1	..	..	..	..	..	2	..	..
Total	27,628	1429		418	676	272	63	133	274	16	673	294	39

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* See detailed classification of woodworkers on page 754.

† See footnote under Table No. 11.

TABLE NO. 11

SECONDARY WATER SUPPLIES TO SPRINKLER SYSTEM.

1922-1923

Primary Supply.	No. of Fires where Secondary Supply was a Factor.	Secondary Supply. Waterworks.	Gravity Tank.	Pressure Tank.	Steam Pump.	Misc. Pump †	Steamer Connection.
Water Works........	52	1	20	1	21	9	..
Gravity Tank........	43	2	2	..	36	3	..
Pressure Tank........	30	6	20	..	2	1	1
Misc. Pumps †........	7	2	3	1	1	..	..
Total...........	132	11	45	2	60	13	1

† Miscellaneous pumps include water supplies reported as automatic steam pump, automatic electric pump, automatic fire pump, fire pump, rotary pump, and pump with no designation of type.

SECTION III

Efficiency of Primary Water Supply

These tables, first printed a year ago, show no important change during the past year. As can be seen from Table No. 2, the pressure tank extinguished 66.6 per cent. of the fires with one or two heads and therefore shows a greater efficiency than the other primary supplies. This is due to the fact that pressure tanks are largely used in occupancies where numerous small fires may occur.

TABLE NO. 1

EFFECT OF SPRINKLERS. 1922-1923

	W.W.	%	G.T.	%	P.T.	%	Pumps.	%	No Data.	Total.	%
Ext. Fire.	633	66.3	214	64.4	426	82.7	66	68.8	12	1351	70.2
Held fire in check	279	29.2	102	30.8	80	15.5	25	26.0	6	492	25.5
Failure ..	43	4.5	16	4.8	9	1.8	5	5.2	10	83	4.3
Total..	955		332		515		96		28	1926	

TABLE NO. 1—Concluded

EFFECT OF SPRINKLERS. 1910-1923

	W.W.	%	G.T.	%	P.T.	%	Pumps.	%	No Data.	Total.	%
Ext. Fire.	6436	64.0	2478	63.3	2812	80.3	677	69.8	96	12499	67.0
Held fire in check	3246	32.3	1312	33.5	648	18.5	263	27.0	54	5523	29.6
Failure . .	373	3.7	123	3.2	43	1.2	31	3.2	56	626	3.4
Total. .	10055		3913		3503		971		206	18648	

TABLE NO. 2

NUMBER OF SPRINKLERS OPERATING. 1922-1923

No. of Sprinklers Operating.	W. W.	%	G.T	%	P.T.	%	Pumps.	%	No Data.	Total.	%
1	329	34.8	91	28.0	233	45.4	34	36.1	6	603	36.4
2	177	18.8	39	12.0	109	21.2	17	18.1	4	346	18.5
3	88	9.3	35	10.7	56	10.9	5	5.3	2	186	9.8
4	68	7.2	29	8.9	30	5.8	5	5.3	1	133	7.0
5	38	4.0	21	6.5	19	3.7	4	4.2	2	84	4.4
6	31	3.3	12	3.8	17	3.3	1	1.1	1	62	3.3
7	27	2.9	11	3.4	9	1.7	4	4.2		51	2.7
8	21	2.2	8	2.5	8	1.5	3	3.2		40	2.1
9	14	1.5	5	1.5	5	1.0	1	1.1		25	1.3
10	17	1.8	2	.6	3	.6	1	1.1		23	1.2
11	11	1.2	6	1.8	6	1.1	1	1.1		24	1.3
12	8	.9	5	1.5	2	.4	1	1.1		16	.8
13	6	.6	7	2.1	2	.4	1	1.1		16	.8
14	5	.5	4	1.2	2	.4	1	1.1		12	.6
15	15	1.6	4	1 2	1	.2				20	1.1
16 to 20.	21	2.2	9	2.8	5	1.0	3	3.2	1	39	2.1
21 to 25.	13	1.4	5	1.5	1	.2	2	2.1		21	1.1
26 to 30.	9	.9	9	2.8	1	.2	3	3.2		22	1.2
31 to 35.	6	.6	4	1.2			2	2.1		12	.6
36 to 40.	10	1.1	4	1.2	1	.2	2	2.1		17	.9
41 to 50.	5	.5	4	1.2					1	10	.5
51 to 75.	8	.9	6	1.8						14	.7
76 to 100	2	.2	3	.9	1	.2	1	1.1		7	.4
Over 100	15	1.6	3	.9	3	.6	2	2.1		23	1.2
No Data	11		6		1		2		10	30	
Total.	955		332		515		96		28	1926	

TABLE NO. 2—Concluded

NUMBER OF SPRINKLERS OPERATING

1910–1923

No. of Sprinklers Operating.	W. W.	%	G.T.	%	P.T.	%	Pumps.	%	No Data.	Total.	%
1	3165	32.0	1112	28.8	1736	49.6	305	31.8	37	6355	34.5
2	1704	17.2	629	16.3	732	20.9	164	17.1	27	3256	17.6
3	934	9.4	373	9.6	329	9.4	85	8.8	16	1737	9.4
4	743	7.5	306	7.9	199	5.7	64	6.7	13	1325	7.2
5	453	4.6	180	4.7	105	3.0	40	4.2	9	787	4.3
6	374	3.8	177	4.6	70	2.0	33	3.4	9	663	3.6
7	273	2.7	113	2.9	49	1.4	30	3.1	7	472	2.6
8	266	2.7	104	2.7	31	.9	23	2.4	6	430	2.3
9	173	1.7	65	1.6	25	.7	19	2.0	3	285	1.6
10	167	1.7	57	1.4	23	.7	11	1.2	3	261	1.4
11	106	1.1	51	1.3	20	.6	10	1.0	2	189	1.0
12	146	1.5	71	1.8	16	.5	9	.9	5	247	1.4
13	83	.8	43	1.1	9	.2	11	1.2	2	148	.8
14	94	.9	35	.9	13	.4	8	.8	2	152	.8
15	77	.8	49	1.3	10	.3	8	.8	1	145	.8
16 to 20.	275	2.8	110	2.8	27	.8	39	4.1	4	455	2.5
21 to 25.	191	1.9	76	2.0	16	.5	22	2.3	8	313	1.7
26 to 30.	121	1.2	57	1.5	14	.4	14	1.5	1	207	1.1
31 to 35.	75	.8	43	1.1	8	.2	10	1.0	4	140	.8
36 to 40.	76	.8	36	.9	9	.2	13	1.4	1	135	.7
41 to 50.	96	1.0	42	1.1	14	.4	8	.8	5	165	.9
51 to 75.	111	1.1	68	1.8	16	.5	11	1.2	4	210	1.2
76 to 100	61	.6	21	.5	5	.1	4	.4	4	95	.5
Over 100	139	1.4	53	1.4	21	.6	18	1.9	10	241	1.3
No Data	152		42		6		12		23	235	
Total.	10055		3913		3503		971		206	18648	

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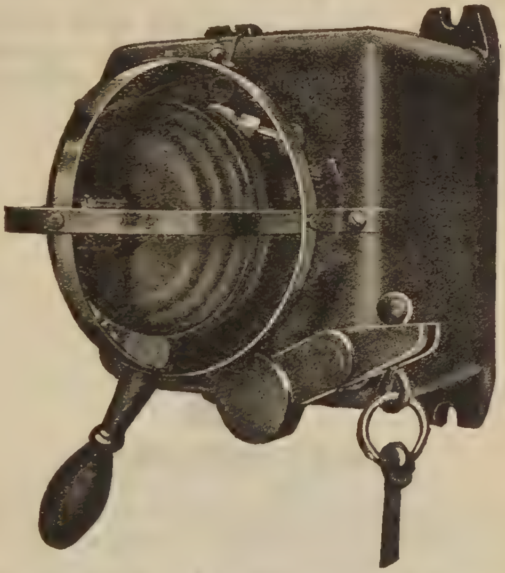

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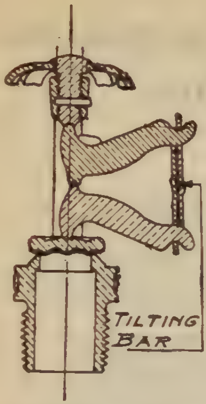

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Globe Sprinklers **Accelerators**
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and other sprinkler equipment accessories are manufactured in our own factories and approved by all insurance interests.

GLOBE
AUTOMATIC SPRINKLER COMPANY
INCORPORATED
REG. U. S. PAT. OFF.

Executive Offices—2035 Washington Ave., Philadelphia, Pa.
Factories—Philadelphia, Pa.; Wheeling, W. Va.

Sales and Engineering Offices:

Atlanta
Baltimore
Boston
Buffalo
Charlotte, N. C.
Chicago
Cincinnati
Cleveland
Dallas
Grand Rapids
Los Angeles
Memphis
Minneapolis
Newark, N. J.
New Orleans
New York
Omaha
Philadelphia
Pittsburgh
Portland, Ore.
St. Louis
San Francisco
Seattle
Syracuse

HEADQUARTERS FOR AUTOMATIC FIRE PROTECTION

For 43 years the Grinnell Company has been the recognized leader in the field of automatic fire protection.

Today its position at the head of the industry is more clearly recognized than ever before, due to the advances it has recently made in the science of fire protection.

On subsequent pages brief descriptions are given of some of the latest devices and service the Company has contributed to the greater safety of life and property in American industry.

Important as are the mechanical elements of Grinnell superiority, they are in reality secondary to the complete engineering, manufacturing and installation organization that operates on a scale wide enough to assure a unique service in every section of the United States and Canada.

Sixty engineering offices; five large fabricating plants at strategic centers; 42 resident foremen and 130 construction foremen supervising a normal road force of 1300 men; a large testing and experimental laboratory. These are the elements which, combined with the recognized superiority of Grinnell devices, place the Company firmly at the forefront of the industry.

If it's fire protection, you can bring your problem to us with the certain knowledge that it will be solved by an organization that for nearly half a century has specialized in all that relates to the automatic extinguishment of fire.

GRINNELL COMPANY

Executive Offices Providence, R. I.

Branch Offices in all Principal Cities in U. S. and Canada

GRINNELL SILICA BULB SPRINKLER

In submitting the Grinnell Silica Bulb head to the Underwriters' Laboratories for approval we made the following claims.

1. Its lower operating point (130 to 145 deg. F) will insure prompter operation in a fire.
2. The method of its operation as compared with the gradual weakening of the solder link sprinkler on rise of temperature results in a greater factor of safety at normal temperatures.
3. The thermally responsive element is absolutely immune to all corrosive influences, with the exception of hydrofluoric acid, which acts on silica much more slowly than on glass.
4. The vigorous bursting action of the bulb makes the sprinkler reliable under all reasonable conditions of loading.
5. The condition of the sprinkler with respect to the performance of its designed function can be positively ascertained by inspection.

ALL OF THESE CLAIMS WERE ALLOWED

GRINNELL COMPANY

Executive Offices **Providence, R. I.**

Branch Offices in all Principal Cities in U. S. and Canada

GRINNELL BOOSTER PUMP SPRINKLER SYSTEM

New, electrically driven, supervised centrifugal pump, draughting from city mains.

Makes tank supplies unnecessary

Provides continuous high pressure service

Secures constant supervision through central station service

These three factors combined make this new development one which eventually must greatly extend automatic fire protection in the many cities where water pressures are now entirely inadequate to the needs of efficient sprinkler protection. Hundreds of buildings structurally incapable of supporting tanks may now be economically sprinklered. If tanks have bothered you, investigate this Booster Pump System.

GRINNELL COMPANY

Executive Offices Providence, R. I.

Branch Offices in all Principal Cities in U. S. and Canada

GRINNELL DRY-PIPE VALVE ACCELERATOR

N. F. P. A. figures indicate that the general use of this remarkable device would save at least $1000.00 on the average in every dry system fire.

Send for special bulletin which describes the accelerator in detail and shows why every dry sprinkler system should be so equipped.

GRINNELL INSPECTION AND SERVICE

Grinnell Company has a force of trained inspectors with headquarters in most of the larger cities in this country and Canada. These men are available to owners of Grinnell sprinkler systems for engineering service and advice.

Grinnell Inspection Service provides a thorough and periodic examination of the sprinkler system and a detailed report is rendered to the property owner. A small annual fee is charged for such service to cover the cost of this work.

Many owners of Grinnell equipments will testify that this service has been of great value to them in improving the condition of their sprinkler system, both from a fire protection and a mechanical standpoint.

A sprinkler system safeguards life and property when maintained in good working order. Grinnell Inspection Service assists the owner of such a system in securing 100% efficiency.

Send for our booklet, "A Stitch in Time."

GRINNELL COMPANY

Executive Offices **Providence, R. I.**

Branch Offices in all Principal Cities in U. S. and Canada

Rockwood Automatic Sprinkler Systems

Rockwood Type D Sprinkler Heads

Rockwood Straight Way Dry Pipe Valves

Rockwood Variable Pressure Alarm Valves

Rockwood Water Motors, Gongs and Hoods

Rockwood Circuit Closers

Rockwood Fusible Fire Door Links

Rockwood Sight Drains

Manufactured and Installed by

ROCKWOOD SPRINKLER CO.

Executive Office and Factory—Worcester, Mass.

Branch Offices in all Principal Cities

Sole Agents for Canada

Worcester Fire Extinguisher Company, Ltd.
Montreal, P. Q.

Other Rockwood Products

PRESSED METAL

ROCKWOOD PRESSED STEEL PIPE UNIONS

ROCKWOOD PRESSED STEEL MACHINE HANDLES

ROCKWOOD ADJUSTABLE PIPE HANGERS

WORCESTER PIPE HANGERS

CONCRETE INSERT BLOCKS AND NUTS

PRESSED STEEL STOVE CAPS

STAMPINGS TO ORDER

ROCKWOOD SPRINKLER CO.

PRESSED METAL DEPARTMENT

Office and Factory

WORCESTER, MASSACHUSETTS

The Phillips Company

Established in 1905

Automatic Sprinklers

Contractors and Engineers

NOTE:—We specialize in supplying automatic sprinklers—terms distributing the cost over a period of years to permit the insurance reduction (from 40% to 90%) to substantially liquidate the transaction.

The Phillips Company

108 S. LaSalle St. *Chicago, Ill.*

Phone: Franklin 4571

SAFEGUARD YOUR ASSETS FROM FIRE WITHOUT DISTURBING WORKING CAPITAL

Any business is worth more than the replacement value of the buildings, machinery and goods that make it up. This non-tangible value can't be covered by a fire insurance policy. Yet fire may destroy it just as effectually as it does the buildings, machinery and stocks you can and do insure.

Automatic Sprinklers are everywhere recognized as the surest protection against fire loss of every kind. One reason why such protection is not installed everywhere is that nearly every thriving business needs all of its working capital in the ordinary development of its trade and does not feel like cutting into working capital to finance the vitally needed fire protection system.

This situation, plus the fact that a sprinkler system reduces insurance cost 50 to 90%, has made our plan of deferred payment sprinkler installation unusually popular, particularly among large concerns where working capital requirements are heavy.

By this plan we pay cash for the sprinkler system installed in your plant. You reimburse us through annual payments over a three, four or five year period. Usually the insurance savings go far towards meeting these payments, often taking care of them altogether. Thus you get the protection your business needs without disturbing your working capital. In many cases you make no expenditure at all except the savings the equipment makes for you.

Insurance is a fixed and necessary expense. Our plan converts that expense into a fixed asset.

Write us for a definite proposition on your plant

U. S. CONSTRUCTION COMPANY

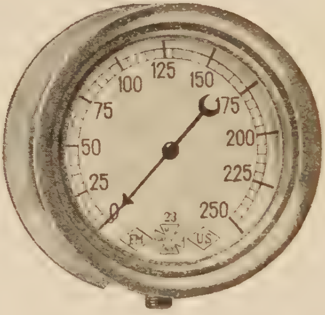
PROVIDENCE **NEW YORK CITY**

PRESSURE GAUGES

FOR

SPRINKLER SYSTEMS

U.S. GAUGE CO. N.Y.



U.S. GAUGE CO. N.Y.

The U. S. Gauge for Sprinkler Systems is constructed as per requirements of both Factory Mutual and Underwriters' Laboratories and is so listed. It is especially designed for use on both wet and dry pipe systems. Manufactured only in the Cast Brass Case 4½" size. Furnished with or without flange on case and with flare or beaded ring. Standard calibrations are 100, 250, and 500 pounds.

U. S. GAUGE CO. NEW YORK

CHICAGO NEW ORLEANS PHILADELPHIA
BOSTON SAN FRANCISCO MONTREAL

ESTY
Automatic Sprinklers

Approved By All Insurance Companies

Two Thirds Size

Installed By

H. G. VOGEL CO.

Established 1895

Executive Offices

15 West 37th Street New York

BRANCH OFFICES

CHICAGO BOSTON CINCINNATI
PHILADELPHIA BUFFALO MONTREAL

Factory
LACONIA, N. H.

Plant
LINDEN, N. J.

No Lead
No Pouring
No Calking

UNIVERSAL
the
CAST IRON PIPE
that Makes
its Own Joints

No bell
holes
to dig

UNIVERSAL
CAST IRON PIPE
FOR FIRE PROTECTION SYSTEMS

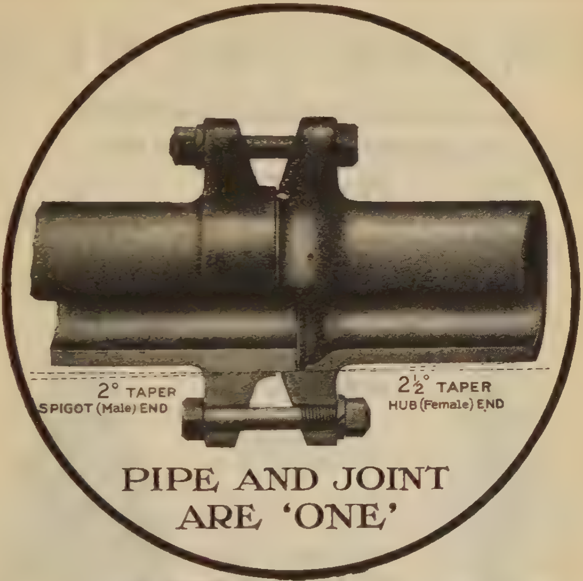
Approved by Underwriters Laboratories
Since 1916

Universal Pipe can be laid in narrow trenches and under water. 6-foot lengths are convenient to handle. Machined hub and spigot joints *stay* tight.

Illustrated Booklets Featuring
Pipe and Fittings upon Request

Write nearest office

THE
CENTRAL FOUNDRY CO.
41 East 42nd St., New York
Chicago Birmingham Dallas San Francisco



Experienced labor unnecessary

Wrenches the only tools

Valves and hydrants of the best known makes are obtainable with the Universal Pipe machined joint connection.

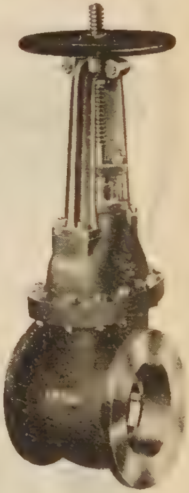
UNIVERSAL CAST IRON PIPE

CRANE VALVES

designed in accordance with the rules and regulations of the

National Fire Protection Association

NO. 510. INDICATOR POST, BONNET TYPE. LENGTH TO SUIT ANY BURY.



NO. 467 IRON GATE VALVE O. S. & Y. RISING STEM 2½" TO 14"

Catalogue No. 51 Contains Much Additional Information. Free on request.

CRANE CO.

Founded by R. T. Crane in 1855

836 South Michigan Avenue
Chicago

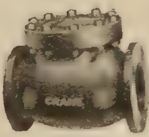
Branches in more than 100 Cities

Works: Chicago and Bridgeport

CRANE VALVES

For Every Fire Protection Need

NO. 459 BRASS GATE VALVE. O. S. & Y. RISING STEM ¾″ TO 2½″



NO. 375 CLEARWAY SWING CHECK VALVE 2½″ TO 12″. BRASS OR LEATHER FACED DISC AS SPECIFIED.

No. 453 BRASS HOSE GATE VALVE FOR STANDPIPES, HYDRANTS AND PUMPS 1½″ AND 2½″

CRANE CO.

Founded by R. T. Crane in 1855

836 South Michigan Avenue
Chicago

Branches in more than 100 Cities

Works: Chicago and Bridgeport

EDDY VALVE CO.

WATERFORD, N. Y.

Manufacturers of

Fire Hydrants, Gate Valves, Check Valves, Foot Valves, Indicator Posts, Etc.

Eddy Fire Hydrants have the following points of superiority

No digging is necessary, for by taking off the cover one man can easily remove the working parts from the standpipe.

No derrick or hoist is required to take the Hydrant apart, nor is a special wrench necessary.

A damaged valve can be replaced by one man in a few minutes and at slight expense.

If the cover should be removed or the standpipe should be broken, no loss or damage can occur due to water escaping, as the valve is held in position from the bottom.

There is a large water way around the Valve when it is opened, and for this reason the **maximum efficiency** is obtained with this Hydrant under fire conditions.

Water hammer is avoided by the Valve closing against the pressure **and the use of the cut-off under the Valve, which gradually closes it.**

Hydrant Stems cannot be bent while using them, as the lower end engages in a threaded nut in the bottom of the Hydrant, and it is simply a case of tension and torsion.

Valve Rubbers are of a quality best adapted for the purpose.

The Bronze Valve Seat is slightly tapering, thus nothing can lodge on it to prevent closing of the Valve.

Frictional loss is reduced to a minimum.

The Drip Rod is at the side of the Hydrant standpipe and independent of the stem. **It can readily be adjusted and can as easily be removed from the standpipe with the main valve closed, without shutting off the water in the street.**

The Drip is automatic and positive in its action, and drains all the water from the standpipe.

With no water in the standpipe, it cannot freeze.

The opening and closing of the Hydrant Valve causes the stem to **raise or lower,** thus **INDICATING** the position of the Valve at all times.

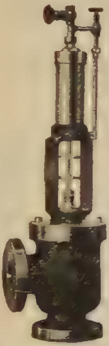
The Hydrant is thoroughly bronze mounted at all bearing parts, efficient, durable, simple in construction and free from the need of costly repairs to keep it in order.

For flushing purposes it has no equal. Whatever can pass the Valve opening will pass out of the standpipe.

No Frost Case is necessary.

EDDY FOR LONG SERVICE

FISHER



The FISHER Type No. 1 Pump Governor has been tested and approved and is listed as standard by the Underwriters' Laboratories. The best recommendation for it is the service record established in years of continuous use. Simple in construction and operation it automatically supplies the correct amount of steam to the pump to maintain the set discharge pressure on the service lines.

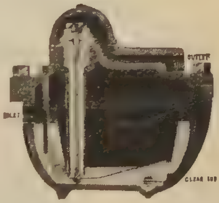
TYPE 33

Dry steam is needed for best operation of your pump. Remove all condensation by using the FISHER Type 33 steam trap.

FISHER on a power plant specialty means SERVICE.

Our agent in your territory will explain these and our many other types to you.

Write us for his name or let us know what your control problem is.



The Fisher Governor Co.

33 Fisher Ave. **Marshalltown, Iowa**

APPROVAL

HERSEY DETECTOR METER

The Hersey Detector Meter has been accepted for sixteen years in 3″, 4″, 6″, 8″, 10″ and 12″ sizes without any restrictions or conditions of any kind by every Insurance Company, Stock and Mutual, doing business in the United States, and by the Water Departments and Water Companies in more than 800 Cities and Towns for use on over 6000 Fire Services protecting over $2,000,000,000 worth of property.

HERSEY MFG. COMPANY

Main Office and Works: South Boston, Mass.

Branches

New York, N. Y.	290 Broadway
Philadelphia, Pa.	314 Commercial Trust Bldg.
Columbus, Ohio	211 Schultz Bldg.
Chicago, Ill.	10 South La Salle St.
Atlanta, Ga.	610 Citizens and Southern Bank Bldg.
San Francisco, Calif.	742 Market St.
Los Angeles, Calif.	218 East Third St.

"ALL KINDS OF METERS FOR ALL KINDS OF SERVICES"

KENNEDY
Valves and Hydrants
for fire protection

Fig. 54

Outside rising stem and yoke valves for sprinkler systems, indicator post valves, hose gate valves, check valves, and hydrants made in accordance with specifications of Associated Factory Mutual Insurance Companies, National Board of Fire Underwriters, National Fire Protective Association, and bear the letters "F. M."

Send for Catalog

THE KENNEDY VALVE
MFG. CO. ELMIRA, N.Y.

New York, Boston, Chicago, San Francisco
El Paso, Salt Lake City, Seattle

Fig. 66

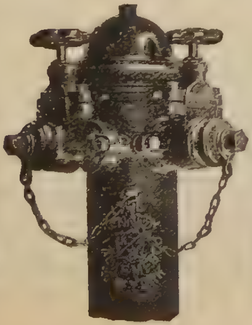
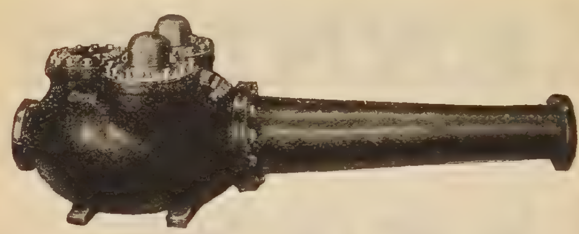


Fig. 110

Fig. 70

Fig. 68



TRIDENT-PROTECTUS

Fire Service Meters

The **First** and **Only** Fire Service Meter

APPROVED

By the

UNDERWRITERS' LABORATORIES

Made in 3″, 4″, 6″, 8″ and 10″ sizes, and designed to meet the following requirements:

Water Works Officials—Accuracy on all flows.

Underwriters—Low loss of head and reliability of operating.

On thousands of Fire Service Meters large quantities of water used daily make extreme accuracy on all flows essential. The Trident Protectus Fire Service Meter marks a distinct improvement over any other type of Fire Service Meter in this important feature of *accuracy of registration* on *all* flows. The Underwriters' requirements for low loss of head or minimum obstruction to flow and *reliability of operation* has been thoroughly and satisfactorily met. Loss of Head Charts furnished on request.

To illustrate: Friction loss in a 6′ Trident Protectus Meter averages 2 pounds from 25 to 1500 gallons per minute, with a maximum at the change over point of 4 pounds.

All parts of the meter are contained in a *single cast iron housing*, built to meet the Underwriters' requirements of seven hundred and fifty pounds per square inch pressure. The low flows are measured through a standard Trident Disc type positive displacement meter while the large, or fire service flows, are measured through a standard Trident Crest Turbine type meter. Both of these meters are equipped with the Standard Trident oil enclosed gear train, thus eliminating corrosion and wear and ensuring freedom from repairs.

The Protectus is the only fire service or other type of meter which provides an unobstructed, full waterway of the same size as the pipe line on which it is installed, thus providing a meter with practically no loss of head and a maximum of capacity.

DIMENSIONS OF METERS

Size	Height	Length of Casing	Length Inches Including Increaser	Breadth	Weight Pounds	Max. Del. Gal. Min.
3″ flange	21¾″	27¾″	64⅜″	22¾′	703	Full
4″ flange	24½″	31¼″	67⅝″	24″	932	Ca-
6″ flange	27¾″	36¼″	84⅝″	29″	1,470	pacity
8′ flange	31″	41¾″	90″	32¾″	2,533	of
10″ flange	37½″	50⅜″	98⅝″	38½″	3,100	Pipe.

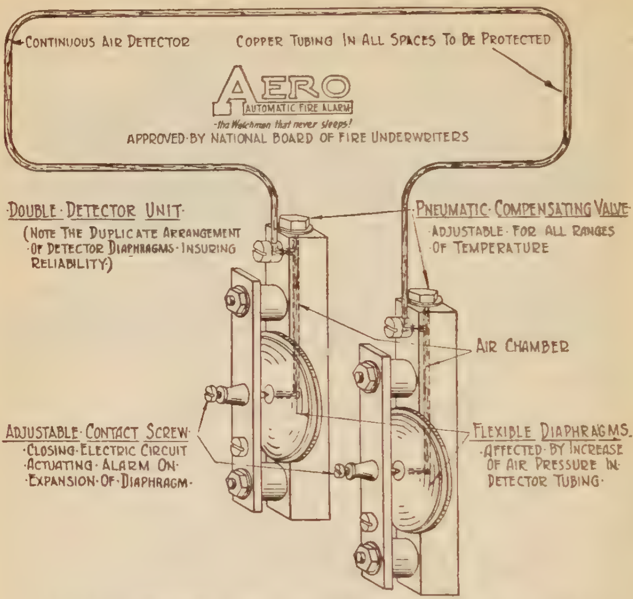
NEPTUNE METER COMPANY

Trident Water Meters, Weber Subterranean Pumps

50 East 42nd Street, New York City

Branches: Atlanta, Chicago, Boston, Denver, Portland,
St. Louis, Cincinnati, Los Angeles, San Francisco

Factories: Long Island City, N. Y., and Toronto, Ont.


CONTINUOUS AIR DETECTOR
COPPER TUBING IN ALL SPACES TO BE PROTECTED
AERO
AUTOMATIC FIRE ALARM
-the Watchman that never sleeps!
APPROVED·BY NATIONAL BOARD OF FIRE UNDERWRITERS
DOUBLE·DETECTOR UNIT·
(NOTE THE DUPLICATE ARRANGEMENT ·OF DETECTOR DIAPHRAGMS·INSURING RELIABILITY.)
PNEUMATIC·COMPENSATING VALVE·
·ADJUSTABLE·FOR ALL RANGES ·OF TEMPERATURE
AIR CHAMBER
ADJUSTABLE·CONTACT SCREW·
·CLOSING·ELECTRIC CIRCUIT ·ACTUATING·ALARM ON· ·EXPANSION·OF·DIAPHRAGM·
FLEXIBLE DIAPHRAGMS.
·AFFECTED·BY INCREASE OF AIR PRESSURE IN· DETECTOR TUBING·

Aero is Standard All Over the United States for Automatic Fire Alarm Service.

AERO automatically detects and reports a fire the instant it breaks out. (Air in the tubing expands when heated and starts the alarm).

Many thousands of buildings now equipped.

Used extensively by the United States Government for protecting Base Hospitals and Warehouses.

The finest passenger ships on the Atlantic and Pacific, as well as the Great Lakes, have installed this System.

Every AERO installation is tested and maintained by expert service men located in all the principal cities of the United States. This expert service is the best guarantee of continuous reliability.

Sold by
American District Telegraph Company
Offices in all principal Cities
Executive Offices: 183 Varick St.
New York City, N. Y.

Exclusive Marine Agents
Chas. Cory & Sons
Cory Building
New York City
N. Y.

AERO ALARM COMPANY

SEATTLE, WASH.
White Building.

NEW YORK CITY, N. Y.
26 Cortland Street.

FIRE PROTECTION

Will prevent loss to your Property and Business by Fire and Water. Reduce your Insurance Costs

ADT SYSTEM

Our Central Stations are directly connected to Fire Headquarters. Apparatus and Systems approved by the Underwriters' Laboratories.

Night Watchman Supervision, combining Manual Fire Alarm Service.

Watchman's Compulsory Tour System, combining Manual Fire Alarm Service.

Manual Fire Alarm Service.

Automatic Fire Alarm Service.

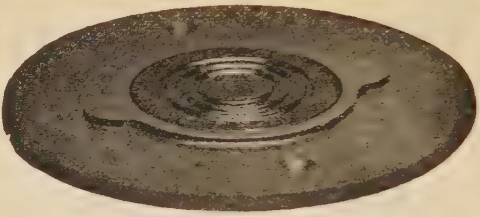
Automatic Sprinkler Supervision, combining Manual Fire Alarm Service.

We protect over $25,000,000,000 of insurable value. We supervise 5,700,000 Sprinkler Heads.

115 Offices 20,000 Subscribers

American District Telegraph Company

183 Varick Street New York City



"Conduit Type"

DERBY FIRE SENTINEL

Approved by the Underwriters' Laboratories and the Fire Dept. of New York City

The **Derby Fire Sentinel**, or fire detector, is simple in construction, having no moving parts; requires no adjustment and is not subject to derangement or false alarms from abuse, corrosive vapors or atmospheric influences.

The **Derby Fire Sentinel** is sensitive, owing to the form in which the solder is made and the heat conductivity of the bronze case. In a standard sprinkler test oven it operates in one-fourth the time required to open an approved automatic sprinkler.

The **Derby Fire Sentinels** are preferably wired on a closed circuit system, so any derangement of the circuit will instantly give a trouble alarm (distinctive from the fire signal). Upon the operation of a Sentinel, fixed resistance is cut out of the circuit, thereby causing the transmitters and local fire gongs to operate. Sentinels are used on wiring systems utilizing primary, storage or public service energy up to 110 volts, D.C. or A.C.

Derby Fire Sentinels are installed in office buildings, hotels, hospitals, schools, museums, libraries, in private dwellings and in ships, in low hazard mercantile buildings and for operating Fire Foam Systems.

Patented in the United States, Canada, England and France. Other patents pending.

DERBY ELECTRIC RELEASE

Approved by the Underwriters' Laboratories and the Fire Dept. of New York City

For closing fire doors, stair and elevator traps and dip tank covers, for opening theater ventilators and dropping theater fire curtains and for shutting down conveyor systems, hot air blower and exhaust systems and engines; also for operating quick opening or closing valves.

It may be operated by one or more of the following methods:

1. By opening of a sprinkler head (sprinkler alarm valve operates electric circuit closer);
2. By operation of automatic fire alarm system;
3. By operation of private manual fire alarm system;
4. By operation of a manual switch.

It is designed to sustain a load or pull of 50 lbs.

Best Approved Device For Closing Fire Doors Because:

1. **It does not wait until the heat reaches the door.** The Release will close the fire door as soon as a sprinkler head or thermostat operates in any part of the fire section.
2. **It is a simple device,** built on proper mechanical lines.

Patented in the United States and Canada. Other patents pending.

AMERICAN FIRE PREVENTION BUREAU, Inc.

1 Madison Avenue **New York City**

THE WATCHMAN'S CLOCK

FOR SERVICE

"THE CHICAGO"

APPROVED PORTABLE

The movement, 8-day, stem-wind, 15-jeweled is the finest product of the famous **Waltham Watch Company,** made especially for this clock. The container case is jar-proof and dust-proof. The registering mechanism and frictionless key action assures an always perfect registration. The lock stations make it available for either in-door or out-door patrol service.

Write for catalogue

CHICAGO WATCHMAN'S CLOCK CO.

1526 S. Wabash Avenue
CHICAGO

9 Church Street
NEW YORK

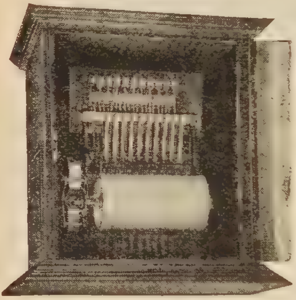
1421 Connecticut Street
LOS ANGELES

25 Minna Street
SAN FRANCISCO

276 Marietta Street
ATLANTA

Eco Electric and Portable Watchman's Clock Systems

Approved and Labeled by Underwriters Laboratories



ELECTRIC CLOCK

PORTABLE CLOCK

Electric Long Life Systems in 6 to 60 station sizes. Tampering without detection impossible. Easily installed. Forty-eight-hour dials over week ends.

Portable clocks are rugged in construction, reliable in operation, and dust- and tamper-proof. Six to thirty station sizes. Twelve or twenty-four hour dials as desired.

Literature on request.

Give real protection and peace of mind to users.

ECO CLOCK COMPANY

Established 1887

Executive Office: 197 Congress Street, Boston, Mass.
26 Cortlandt Street, New York

Branches in Principal Cities listed in Telephone Books under
ECO CLOCK COMPANY

We are the only manufacturers of both portable and electric watch clocks

FEELS FIRE

FIRE DETECTION SERVICE

REPORTS INSTANTLY

REGISTERED TRADE MARK

Fire Detection Service

The field experience (dating from 1914) of Fire Detection Service (Reichel System) has set a standard for fire protection by signaling systems. This has been accomplished by sound fundamental scientific principles of Thermopiles as fire detectors installed with highest grade materials, backed up by unrelenting persistence in efficient maintenance and operation details.

Fire Detection Service (Reichel System) is the only approved, compensating, or Rate-of-Rise of temperature alarm or fire detecting system commercially available in the United States in which all fire detector circuits are under constant electrical test.

Devices not sold outright but installation made only by lease contract where operation can be supervised either by an approved Central Station, or by this company's organization when systems are connected as an auxiliary to Municipal Fire Alarm Systems.

FIRE DETECTION SERVICE

General Offices—440 Howard Street, San Francisco

FIRE ALARM SYSTEMS

1. Complete systems independent of the city fire alarm system for large industrial plants having their own fire brigades.

2. Auxiliary systems (*Shunt Type*) which make it possible to send alarm to city fire department from any part of your factory. No local battery.

3. Combined systems for summoning the city fire department at the same time that the local plant brigade is notified.

Our Industrial Engineers will be pleased to give you the benefit of the knowledge we have accumulated the past fifty years in installing such systems.

THE GAMEWELL COMPANY

Newton Upper Falls, Massachusetts

CAUTION AND DANGER SIGNS

To Aid FIRE and ACCIDENT PREVENTION

We carry in stock or make on short notice signs to meet every need: A full line of electrical signs, on fibre where voltages are high; signs for cleanliness and order, no smoking, exits, hazardous materials, location of fire apparatus, use of matches, closing of firedoors, etc. Tell us your needs.

Literature upon request

Stonehouse SIGNS, INC.

STONEHOUSE BLDG. 842 LARIMER ST. DENVER, COLO. U.S.A.

"The Standard"

Portable Watchman's Clock

Over 89,000 in use. Approved and labeled by the Underwriters Laboratories and the Associated Factory Mutual Fire Insurance Companies.

Will allow very liberal discount or commission to parties who wish to handle these clocks. Write for circular giving full information and prices.

E. O. HAUSBURG
51 Maiden Lane New York

Holtzer-Cabot
BUSINESS ESTABLISHED 1875

SIGNALING AND PROTECTIVE SYSTEMS

Fire Alarm
Fire and Watch
Watchman's Recording
Telephone
Factory Call

Simple, safe, and reliable Signaling and Protective systems have been manufactured over a period of 40 years by the Holtzer-Cabot Electric Company and are invariably specified by the leading architects and engineers of the country.

Industrial engineers are requested to send for descriptive literature

The Holtzer-Cabot Electric Co.
Home Office and Factory
125 Amory Street, Boston Mass.

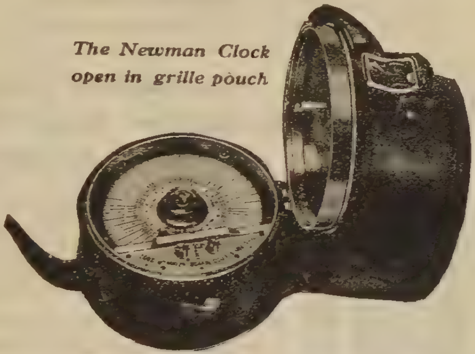
Branch Offices

Chicago, Ill., 6161–65 So. State St.,
New York, N. Y., 101 Park Ave.,
Philadelphia, Pa., 807 Otis Bldg.
Detroit, Mich., 1051 Book Bldg.
Cleveland, O., 517 Union Bldg.
Baltimore, Md., 1104 Union Trust Bldg.
Minneapolis, Minn., 627 Metropolitan Life Bldg.
Atlanta, Ga., 1511 Healey Bldg.

NEWMAN WATCHMAN'S CLOCKS

"A Positive Check on Human Fallibility"

Labeled by Underwriters Laboratories and accepted as Standard by all insurance interests



The Newman Clock open in grille pouch

The Newman System equipped the watchman with a portable watch-clock which must be carried in rotation to patrol stations on every hourly inspection round, each having a key which when inserted and turned in the clock registers on a paper dial therein the distinctive number of that station and the exact time at which it was visited.

Outfits complete consist of the watch, leather pouch with carrying strap, station boxes with marking keys attached, seals and one year's supply of paper dials.

Newman Grille Watch-clocks are manufactured in the following standard sizes; 6, 9, 12, 16, 20, 25, and 30 stations. Weight ranges from 2½ to 3¼ lbs.

NEWMAN CLOCK COMPANY, Inc.

Founded in 1872

428 Broadway	**440 Howard Street**	**565 W. Washington Blvd.**
NEW YORK, N. Y.	**SAN FRANCISCO, CAL.**	**CHICAGO, ILL.**

Associated Companies

Newman-Munderloh Clock Co., Ltd., 51 Victoria Sq., Montreal, Canada
Newman Clock Co., Ltd., 2 Whitechapel Road, London, England
C. E. Carpenter Co., S. A., 57 Rue du Richelieu, Paris (2e), France

BADGER'S

Chemical Fire Apparatus

Built under the supervision of the Underwriters' Laboratories

Warehouse Type 33-Gallon Engine for use inside buildings

Strongly built and absolutely proof against corrosion. They are lined with sheet lead about ⅛ inch thick thoroughly attached to steel shell.

Every "Badger" Engine is tested to 350-lbs. cold water pressure.

Carries 50 feet of hose and will throw stream 75 feet beyond nozzle.

TRUCK TYPE OF

Chemical Fire Engine

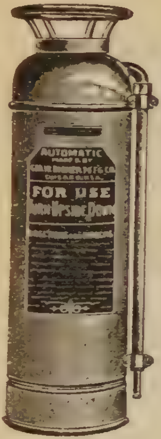
33 gallon for outdoor use

Also 2½ Gal. Hand Chemical Fire Extinguisher

MANUFACTURED BY

Badger Fire Extinguisher Co.

175 Portland St., Boston, Mass., U. S. A.
NEW YORK OFFICE . . 123 William Street



2¼ Gallon
Chemical Extinguisher
$18.00 Each

EXCELSIOR CANS

1 Bale	20″x28″x36″	Each	$20.00
2 Bale	20″x52″x36″	"	30.00
3 Bale	40″x52″x36″	"	50.00

Made also with fusible links and casters at additional cost.

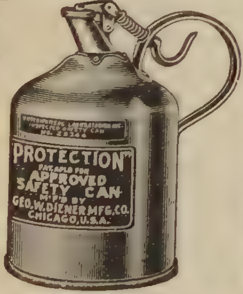
SAFETY CANS

Size	Each
1 Pint	$1.75
1 Quart	2.00
2 Quart	2.50
1 Gallon	3.00
2 Gallon	3.50
3 Gallon	4.50
5 Gallon	5.50
10 Gallon	8.50

5 Gal. Pump Ext.
$12.00 each
Non-Freeze Charge
$2.00 each

WASTE CANS

No.	Capacity		List Each
11	6	Gal.	$ 3.00
22	10	"	4.50
33	15	"	6.00
44	25	"	9.00
55	40	"	13.00



APPROVED PROTECTION AND PREVENTION APPARATUS

Manufactured by

Geo. W. Diener Mfg. Co., Chicago, Ill.

Discounts quoted to Agents, Jobbers and Dealers.

REAL PROTECTION MEANS

the right extinguisher in the right place

Hotel, factory, office building—they may be equipped with fire extinguishers—plenty of them—but the point is—*will these extinguishers check a fire?*

Fire protection does not merely consist of buying extinguishers, of one type or another, and hanging them on the wall.

In such haphazard protection the fire risk may be almost as great as if you had not a single extinguisher in your building.

Real protection means: *the right extinguisher in the right place.*

It's not a problem for guesswork—a fire is too serious a matter. It's a job for specialized engineers to tackle.

And that's the real strength of the Foamite-Childs Corporation. When you buy Foamite-Childs fire protection you are buying more than just an extinguisher or an extinguishing system—you are getting, too, the specialized knowledge and experience of the Foamite-Childs fire protection engineers.

You know that you are getting from Foamite-Childs men the type of extinguisher best fitted in every way to protect you from fires.

You know that you have received expert, unbiased advise on the placing of this apparatus at the most strategic points.

The Foamite-Childs Corporation is the leading organization manufacturing fire apparatus and functioning in a complete way, in the capacity of fire protection engineers.

As manufacturers of all types of fire extinguishers and apparatus, Foamite-Childs men are not interested in selling one type rather than another.

We are only anxious for you to get those extinguishers or engines which will give you the greatest possible protection.

There is a Foamite-Childs product for every fire protection purpose requiring chemical equipment:

"FOAMITE" hand fire extinguishers, portable engines on wheels, systems for the extra-hazardous risks, indoors and outdoors, on land and sea. Exclusively a Foamite-Childs development. "Smothers fire with Firefoam"

"CHILDS" Soda-and-acid extinguishers, portable engines, and motorized equipment on various commercial truck chasses. (The standard for ordinary fire risks.)

"FIRE GUN" Carbon-tetrachloride (pump gun type) hand extinguisher—1 qt., 1¼ qt., and 1½ qt. sizes. (For first-aid protection against small fires in your automobile, and live electrical risks.)

"ALLWEATHER" Non-freezing extinguisher.

Let the Foamite-Childs engineers work with you in specifying adequate fire protection for your plant.

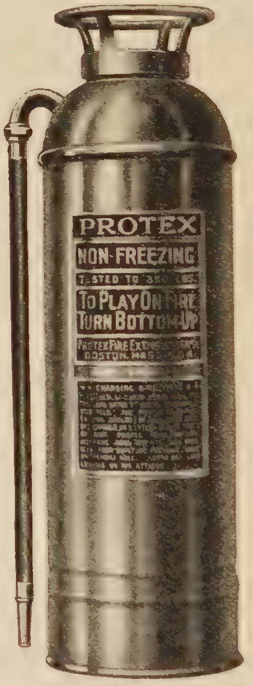
Foamite PROTECTION
SMOTHERS FIRE
Foamite-Childs Corporation
ENGINEERS AND MANUFACTURERS
UTICA, N.Y. U.S.A.
PATENTED IN UNITED STATES
AND IN FOREIGN COUNTRIES
PATENTS PENDING

Foamite-Childs Corporation

Fire Protection Engineers and Manufacturers
501 Turner St.,
Utica, N. Y., U. S. A.

Sales and Engineering Representatives in the leading cities of all countries

PROTEX
NON-FREEZING
FIRE EXTINGUISHERS



Protect your property twelve months of the year regardless of whether the temperature is 40° below zero or 100° above. Operates by chemical reaction.

Overcomes the difficulties of freezing found in the ordinary soda and acid type which must never be exposed to temperatures below 40° above zero.

Send for Information

Price
$20.00

Also Other Types of Approved Extinguishers and Engines
Manufactured by
PROTEX FIRE EXTINGUISHER CO.
176 FEDERAL STREET BOSTON, MASS.

Wirt's Plate AA Hose Station

The most modern and economical method to care for linen fire hose is to put it on Wirt's Racks in Wirt's Steel Hose Cabinets.

We make a specialty of and manufacture

FIRE HOSE OUTFITS

Reels, Racks, Carts

and all types of Fire Fighting Equipment for buildings, factories, railroads and manufacturing plants.

Send for our literature.

Booklet J describes Hose Cabinets, Racks, Reels, Hose Valves, etc.
Catalog A-21 describes Hose Carts, Reels, Hose House Equipment, Sundries, etc.

WIRT & KNOX MFG. CO.,

2309 York Street **PHILADELPHIA, PA.**

CEMENT-GUN
TRADE MARK

Employs compressed air to force sand and cement under high velocity against a surface. The resultant material is called "gunite."

Underwriters Laboratories have given gunite exterior walls properly reinforced (two 2″ slabs with 8″ air space) a three hour rating, and given a 2″ solid interior wall (non-bearing) a one hour rating. Philadelphia was the first city to rate these constructions the equivalent of brick exterior walls and brick enclosures for vertical shafts.

Gunite can be used to protect any structural member to any depth. It offers the only method effectively to repair structures damaged by fire, sea water, or other causes.

Gunite has these chief advantages: Economical construction; imperviousness; very high resistance to fire; unaffected by gas or fumes; bonds perfectly to brick, tile, or concrete; twice the strength of ordinary concrete.

The "Cement-Gun" is sold outright. We act as consultants on all forms of concrete construction and repair problems. Illustrated bulletin upon request.

Cement-Gun Company, Inc.
Allentown, Pa.

CORNELL--DERBY

Non-Freezing

Standpipe Fire Line System

In response to the demand for a reliable non-freezing and self-supervised standpipe fire line system for the protection of piers, train sheds, warehouses and all unheated buildings, the W. G. Cornell Company, operating under the Derby patents, offers the Cornell-Derby Non-Freezing Standpipe System.

Detailed information regarding this system will be furnished on request.

W. G. CORNELL COMPANY

Everett Building **New York**

Fire Protection

Plumbing ***Heating*** ***Lighting***

One-Hour Rating for Metal Lath Protected Lumber

The most important development since the introduction of "fire-proof" construction

Underwriters' Laboratories, November 8, 1922, announces a classification hitherto unrecognized in the protection of construction with wood structural supports.

By the use of metal lath and plaster applied to walls and ceilings of ordinary wood construction the Laboratories' engineers have found protection for periods greater than one hour and have accorded the remarkably high rating of one hour upon floors and bearing partitions so constructed.

Considered in the light of fire statistics which show that ordinary lath and plaster or substitutes frequently fails in ten minutes or less, tremendous possibilities are now open for inaugurating a new era of fire-resistive frame construction.

The following are positions in ordinary building construction where expanded metal lath and plaster on lumber joists and studs are particularly advantageous from a fire protection standpoint:

Basement ceilings, especially over heating plants and fuel storage rooms, walls back of ranges in all types of buildings; walls and ceilings enclosing public halls or stairs and underside of stair carriages in flat and apartment buildings; division walls between apartments; ceilings around stairs and over stores when living quarters or public assembly are permitted above; and walls and ceilings of attached garages when built with lumber studs or joists.

It is also especially recommended for floors, bearing partitions, and all other structural lumber (mill construction excepted) in public buildings such as banks, court buildings, churches, schools, hospitals, institutions, and hotels, and in factory or mercantile establishments over two stories high.

METAL LATH
Stops Fire
Prevents Cracks

Our Engineering Department will gladly supply full information

Address

Associated Metal Lath Manufacturers

123 W. Madison Street **Chicago, Illinois**

For Protection Against Fire and Burglary

STEELCRETE ARMORED VAULTS

Federal Reserve Banks

New York
Jacksonville
Nashville
Oklahoma City
New Orleans

Designs—Estimates—Interviews on Request

Steelcrete

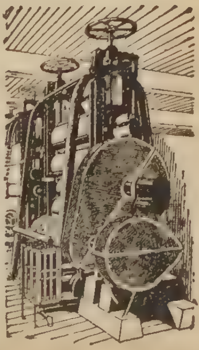
Steelcrete used with plaster is ideal for protection of structural steel and the construction of enclosures, partitions, and ceilings.

For Protection Against Loss of Life and Limb

STEELCRETE SAFETY GUARDS

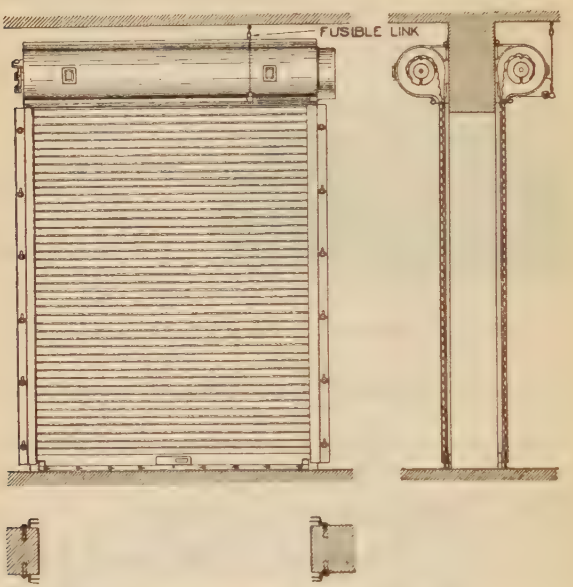
Write for the Machine Guard Hand book. Sent free on request.

The Consolidated Expanded Metal Companies.
Braddock, Pa.
Pittsburgh *Chicago*
New York *Philadelphia*



The Kinnear Manufacturing Company

20 Field Ave., Columbus Ohio



Steel Rolling Fire Door For Opening In Fire Wall
Inspected and Labeled by The Underwriters' Laboratories, Inc.

Approval: Double doors, opening not exceeding 80 sq. ft. in area, nor 12 ft. in width or height.

Description: Mounted on opposite faces of wall.

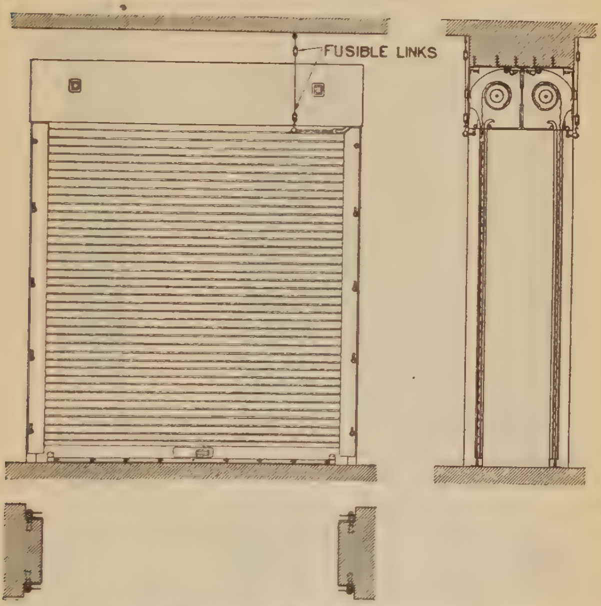
Normal operation—Door is raised and lowered manually by means of a handle in the bottom of the curtain, fully counterbalanced so that operation is easy.

Automatically closed in event of fire by fusible link.
This door is not difficult to operate after it has automatically closed and can be easily raised.

For elevator openings, a single door of similar construction with lighter gauge curtain is approved.

The Kinnear Manufacturing Company

20 Field Ave., Columbus, Ohio



Steel Rolling Fire Door For Opening In Fire Wall

Inspected and Labeled by The Underwriters' Laboratories, Inc.

Approval: Double doors, opening not exceeding 80 sq. ft. in area, nor 12 ft. in width or height.

Description: Mounted in opening.

Normal operation—Door is raised and lowered manually by means of a handle in the bottom of the curtain, fully counterbalanced so that operation is easy.

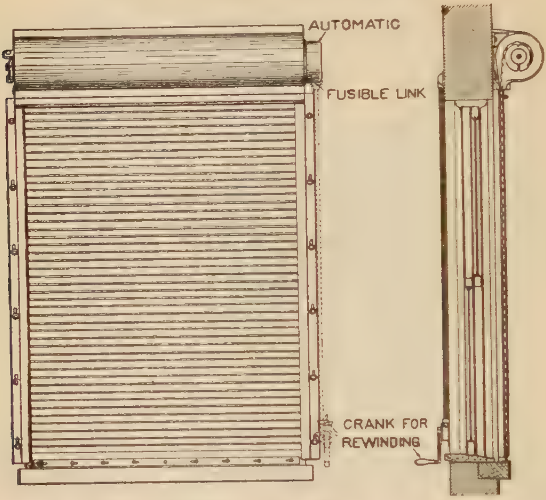
Automatically closed in event of fire by fusible link.

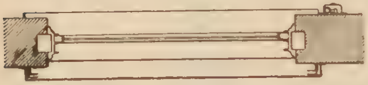
This door is not difficult to operate after it has automatically closed and can be easily raised.

For elevator openings, a single door of similar construction with lighter gauge curtain is approved.

The Kinnear Manufacturing Company

20 Field Ave., Columbus, Ohio





Steel Rolling Shutter For Exterior Openings,
Inspected and Labeled by The Underwriters' Laboratories, Inc.

Approval: Single shutter not exceeding 100 sq. ft. in area, nor 12 ft. in width or height.

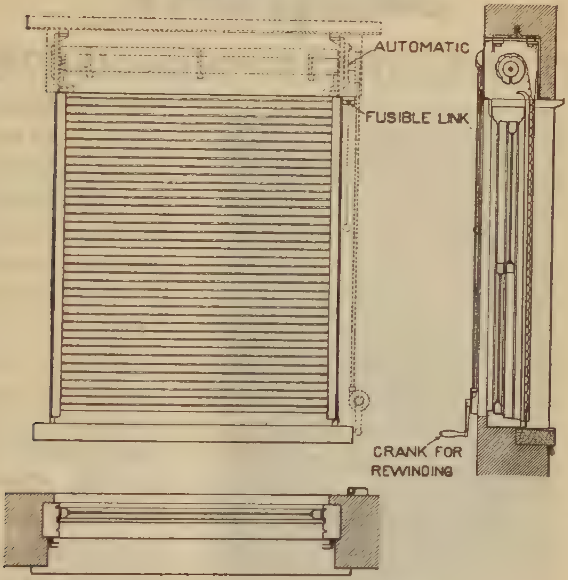
Description: Mounted on exterior face of wall, and equipped with gearless rewinding device operated from the inside. The coil and automatic mechanism is enclosed and fully protected from the weather.

Shutter is normally open. Automatically closed by fusible link in event of fire.

Catalogs of special information will be furnished upon request.

The Kinnear Manufacturing Company

20 Field Ave., Columbus, Ohio



Steel Rolling Shutter For Exterior Openings,
Inspected and Labeled by The Underwriters' Laboratories, Inc.

Approval: Single shutter not exceeding 100 sq. ft. in area, nor 12 ft. in width or height.

Description: Mounted in reveal above the window frame and equipped with gearless rewinding device operated from the inside.

Shutter is normally open. Automatically closed by fusible link in event of fire.

The Kinnear Manufacturing Company

Columbus, Ohio, U. S. A.

Branches at
Boston, Mass. Chicago, Ill. Cleveland, Ohio Detroit, Mich.
Philadelphia, Pa. Kansas City, Mo. Washington, D. C. New York
Pittsburgh, Pa. New Orleans, La. San Francisco, Cal.

Lupton

STEEL SASH PRODUCTS

Double Hung Steel Plate Window Type B

Fine Solid Steel Casements: Double Hung Steel Plate Windows for banks, offices and monumental buildings.

Solid Steel Projected and Counterbalanced Sash, for schools, offices, and hospitals.

Solid Steel Pivoted Factory Sash, Pond Contінous Sash and Operating Device, and Counterbalanced Sash for side walls and roofs of industrial buildings.

Solid Steel Projected Windows, "out-at-side," and Basement Windows for apartments and residences.

All types except Casements, Pond Continuous Sash and residence windows are made to bear Underwriters' Labels where required.

Steel Doors and Partitions for factories and factory offices. [illegible] *for information.*

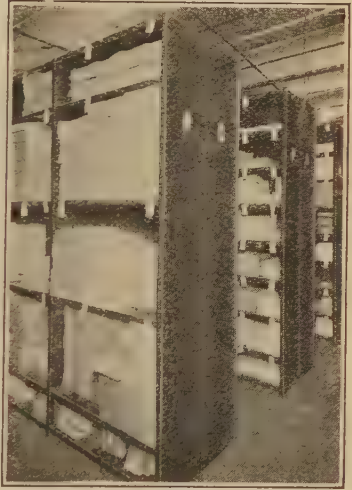
Lupton

STEEL FACTORY EQUIPMENT

Bin Type and Rack Type Steel Storage Shelving in stock and special sizes for heavy duty. Easily erected, adjusted and relocated when needed.

Steel Unit Shelving (portable units) for stores and light miscellaneous storage. Bins are of assorted sizes to hold variety of contents.

Pressed Steel Bench Legs, Bench Drawers, Tool Cabinets, Utility Cabinets, Foremen's Desks, etc.



Bin Type Storage Shelving for heavy duty

Lupton Auto Parts Storage: special steel bin systems for "filing" parts in related groups.

Steel Wheel and Tire Racks, Fender Racks, Bar Racks, etc., for garages.

Steel Display Counters and Display Shelving for retail stores.

DAVID LUPTON'S SONS COMPANY
PHILADELPHIA

Chicago New York Pittsburgh Boston
Cleveland Detroit Buffalo
St. Louis Atlanta Baltimore
Dallas

ESTABLISHED 1866

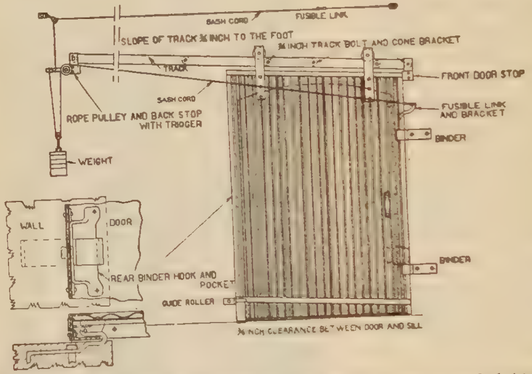
M & E
TRADE MARK

FIRE DOORS "ALMETL" FIRE SHUTTERS
REG. U.S. PAT. OFF.

UNDERWRITERS LABELED

Universally approved by all Insurance (Stock and Mutual), City, State, and National Fire and Safety Control Authorities. Highest Insurance Credit.

LIGHT


SASH CORD
FUSIBLE LINK
SLOPE OF TRACK ⅜ INCH TO THE FOOT
¾ INCH TRACK BOLT AND CONE BRACKET
TRACK
FRONT DOOR STOP
SASH CORD
FUSIBLE LINK AND BRACKET
ROPE PULLEY AND BACK STOP WITH TRIGGER
BINDER
WEIGHT
WALL
DOOR
REAR BINDER HOOK AND POCKET
BINDER
GUIDE ROLLER
⅜ INCH CLEARANCE BETWEEN DOOR AND SILL

RIGID

Made entirely of Steel and Asbestos. A panel of transversely laid 2½ in. corrugated galvanized heavy gauge steel, interlined with asbestos—all securely held in a continuous frame of 2½ in. x 3/16 in. bar steel. All joints are welded or riveted. The frame and ends of panel sheets are protected by a cover binder of heavy galvanized sheet steel, riveted to the frame. The cross laid corrugated sheets give maximum strength, with minimum weight.

IMPASSABLE BY FIRE INDESTRUCTIBLE IN USE

Write for catalog and engineering details
Contracting and erecting licenses everywhere

FIRE RETARDING "STAR" VENTILATORS

Are equipped with a gravity closing damper and are so arranged that in event of fire the damper closes automatically. Maximum exhaust, minimum cost.

MERCHANT & EVANS Co
NEW YORK PHILADELPHIA CHICAGO
LANCASTER, PA. CLEVELAND
KANSAS CITY WHEELING
DETROIT

Peter's Approved Hardware

Labeled by Underwriters' Laboratories

FIRE DOOR AND SHUTTER HARDWARE
in Standard Sets ready to install or made to meet any special condition

PETER'S APPROVED PANIC LATCHES
for Fire Doors; also Panic Exit Door Bolts.

AUTOMATIC FIRE WINDOW LATCHES
and Ventilator Controlling Mechanism.

CATALOGUE AND PRICES ON REQUEST

JAMES PETERS & SON

Established 1869

1934-38 No. Front St. Philadelphia, Pa.

FERALUN

Anti-Slip Treads

Stair Treads Fire Door Saddles Elevator Thresholds

"**Feralun**" is iron and emery cast together, is durable, fire resistant and affords a safe foothold on walkway surfaces.

For floor plates in Engine and Boiler rooms and around moving machinery, where there is oil, soapy water, etc., it prevents serious accidents from slipping and falling.

In buildings of the highest class, where a fine architectural effect is desired use "**BRONZALUN**" or "**ALUMALUN.**"

Samples and Literature on Request.

AMERICAN ABRASIVE METALS CO.

50 CHURCH STREET, NEW YORK

The Seal of Window Protection

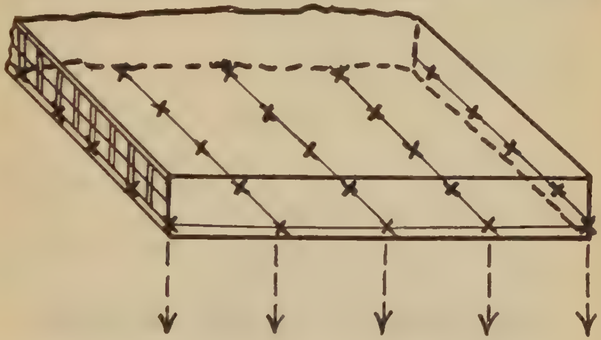
Let us co-operate with you on your problems of protecting window openings, enclosing stair and elevator wells, sub-dividing floor areas, etc.! Our descriptive literature and samples will be of service to you and will be gladly sent upon request.

MISSISSIPPI WIRE GLASS CO.
220 Fifth Avenue,
NEW YORK
CHICAGO
ST. LOUIS

FACTROLITE

FOR INDUSTRIAL BUILDINGS AND WHY

On the basis of plain glass giving 100% illumination, the photometric measurements in the chart below show how Factrolite increases the illumination at the most important point which is 25 feet or the middle of a 50 foot wide building 72% while at locations near the window the light is reduced by complete diffusion to eliminate glare.



Average Illumination with	Wdo.	12½ ft.	25ft.	37½ ft.	50 ft.
		Photometric Measurements			
Clear Glass Windows	28	16.8	1.4	0.80	0.85
Factrolite Wire Glass	25	12.7	2.41	1.10	1.28
% of increase in illumination			72	38	57
% of decrease in illumination	11	25			

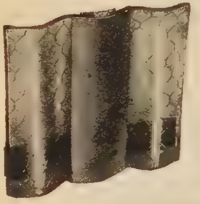
Laboratory reports and our full co-operation will be given upon request.

MISSISSIPPI WIRE GLASS COMPANY
MISSISSIPPI GLASS COMPANY

7 W. Madison Street CHICAGO	220 Fifth Avenue NEW YORK	4070 N. Main Street ST. LOUIS

CORRUGATED WIRE GLASS

The acknowledged new standard for



ROOFS SKYLIGHTS

SIDE WALLS CANOPIES

AREA COVERINGS

Seven times stronger than flat glass of same thickness.

No glare, greater illumination.

No steel sash required.

Nothing to wear out or deteriorate.

Withstands vibration.

Approved by the Investigating Committee of Architects and Engineers. Report sent on request.

Send for new forty page illustrated catalog giving views of installations and engineering data.

AQUEDUCT WIRE GLASS

The ONLY glass manufactured in the world today which prevents dripping from condensation.

Also manufacturers of 1/8″ wire glass (Rough, Ribbed, and Figured). For safety, use this glass, as it will not scatter when broken.

Our wire glass, 1/4″ and over in thickness, has the full approval of the National Board of Fire Underwiters as a fire retardant. Catalog and samples on request.

Pennsylvania Wire Glass Company

Pennsylvania Building **Philadelphia, Pa.**

Actinic Glass

(Trade Mark)

A heat intercepting glass (amber tinted) that excludes 85% of the Ultra-Violet (glare) rays and not only prevents the deterioration of fabrics, such as silk and rubber, but also prevents the harmful effects of these rays on the eyes.

The Infra-Red (heat) rays have been authoritatively proven to tire the eyes. By excluding 55% of these rays, eye fatigue—with its resultant inefficiency—is eliminated by Actinic glass.

This glass is particularly desirable for use in school windows to protect the children's eyes.

Prevents fading of colors.

Made in various patterns, with and without wire, to suit all requirements.

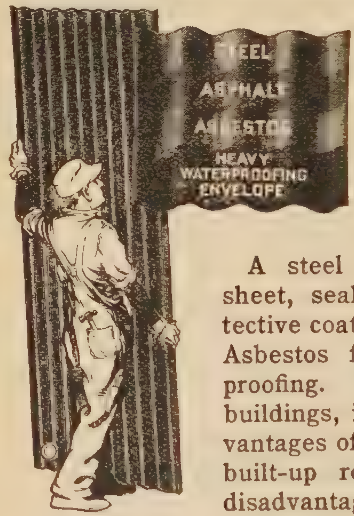
Actinic Glass tested by the United States Bureau of Standards. (Report on request.)

It may be the one glass that will solve your problem.
Our Engineering Staff will advise you—Free.

Pennsylvania Wire Glass Company

Pennsylvania Building **Philadelphia, Pa.**

Robertson Process
Asbestos Protected Metal



RPAPM
TRADE MARK REG. U.S. PAT. OFF.

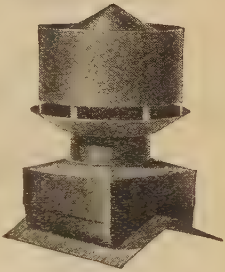
A steel roofing and siding sheet, sealed in a triple-protective coating of (1) Asphalt, (2) Asbestos felt and (3) Waterproofing. Used on industrial buildings, it combines the advantages of corrugated iron and built-up roofings without the disadvantages of either.

Robertson Process Asbestos Protected Metal (APM) successfully resists the destructive action of weather exposure, smoke, steam, fumes, gases, condensation, salt air—all corrosive influences. This kind of durability means the greatest possible roof economy. The moderate first cost of APM is spread over so many years of service that its cost per year is remarkably low. And the first cost of APM is practically its only cost, because it never requires painting and because upkeep expense is eliminated under most conditions.

Write for prices, descriptive literature
and a sample of the material itself.

H. H. ROBERTSON COMPANY
PITTSBURGH, PA.

A New Ventilator of Greater Efficiency



The new Robertson Ventilator is a roof ventilator of unusually powerful exhaust capacity under all conditions of wind, weather and temperature.

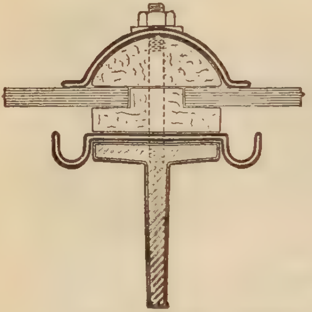
The exceptional air-pulling capacity of the Robertson Ventilator is indicated by the fact that *it exhausts from 50 to 60% more air than an open pipe*—a most unusual rating as compared with the exhaust capacities of ventilators of other types—whether stationary or rotary.

The Robertson Ventilator ventilates as efficiently at low wind velocities as at high. It performs as satisfactorily on sloping roofs as on flat roofs—an advantage that few ventilators possess.

The Robertson Ventilator is a strong, immovable, rigidly-constructed unit. It has no rotating parts to get out of order or require attention. Operating expense and upkeep expense are eliminated. Robertson Ventilators are made of Asbestos Protected Metal, copper or galvanized iron as specified. Write for complete details and prices.

H. H. ROBERTSON COMPANY
PITTSBURGH, PA.

ROBERTSON
Skylight Construction



Cross Section Robertson Skylight Construction

Robertson Skylight is a patent glazing contruction of unusual durability. Its long life is due to the use of Robertson Process Asbestos Protected Metal (APM) and Robertson Process Asphalt. It is a skylight that cannot corrode or rust and does not require painting.

The danger from broken glass through corrosion and deflection of supporting bars and the expense of such breaking is eliminated.

The bar, condensation gutter and cap are made of APM. It is readily apparent that skylight construction made of metal, so fully protected, will have many years added to its life.

Robertson Process Asphalt is used for the skylight cushion and fillers. This special asphalt provides a non-absorbent, resilient, permanent, and insulating bed for the glass.

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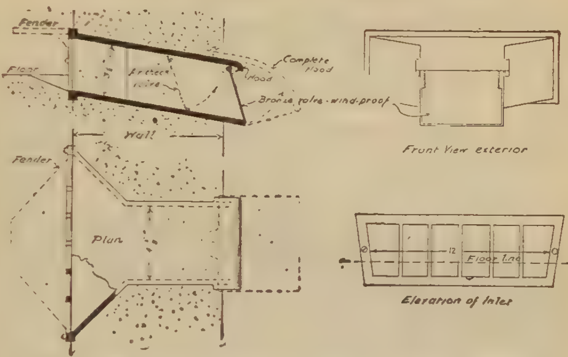

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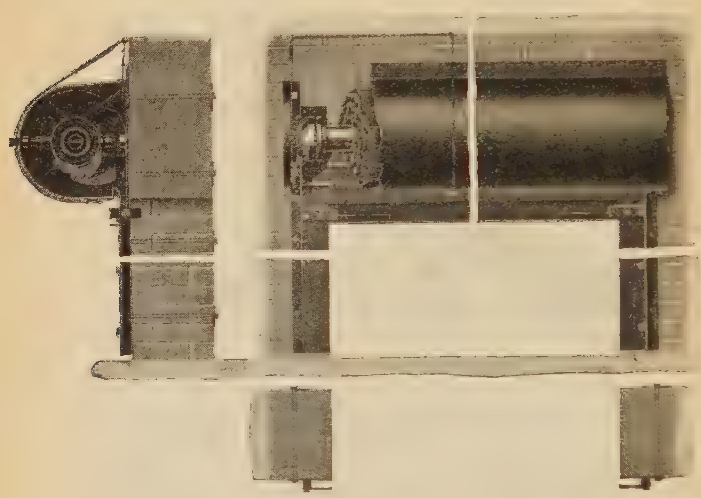

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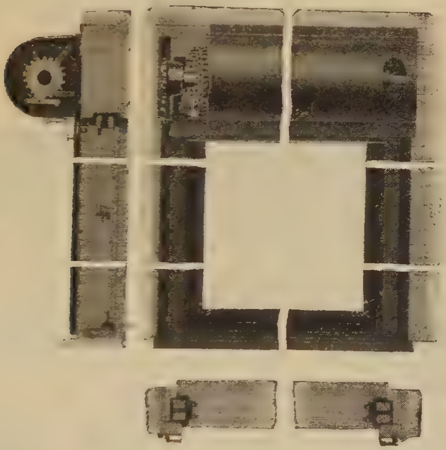

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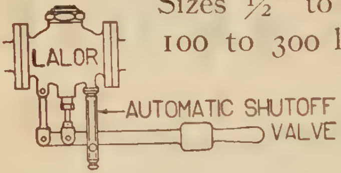

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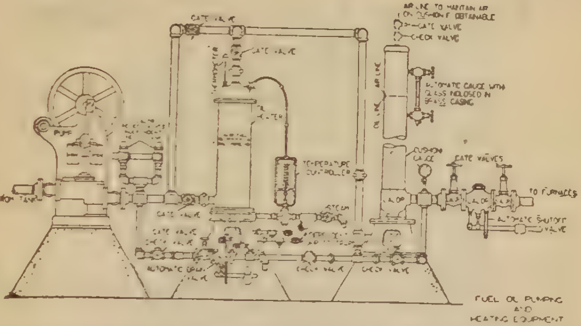

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141 B	3 hr.	7.68	169	1300	12.84
143 B	3 hr.	7.68	221	1700	19.26
144 B	3 hr.	9.82	203	2000	27.05
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Zinc, corrugated ... 213 (3–g), 214 (4–g)
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Zinc dust, spontaneous combustion ... 104 (244), 119 (8)

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